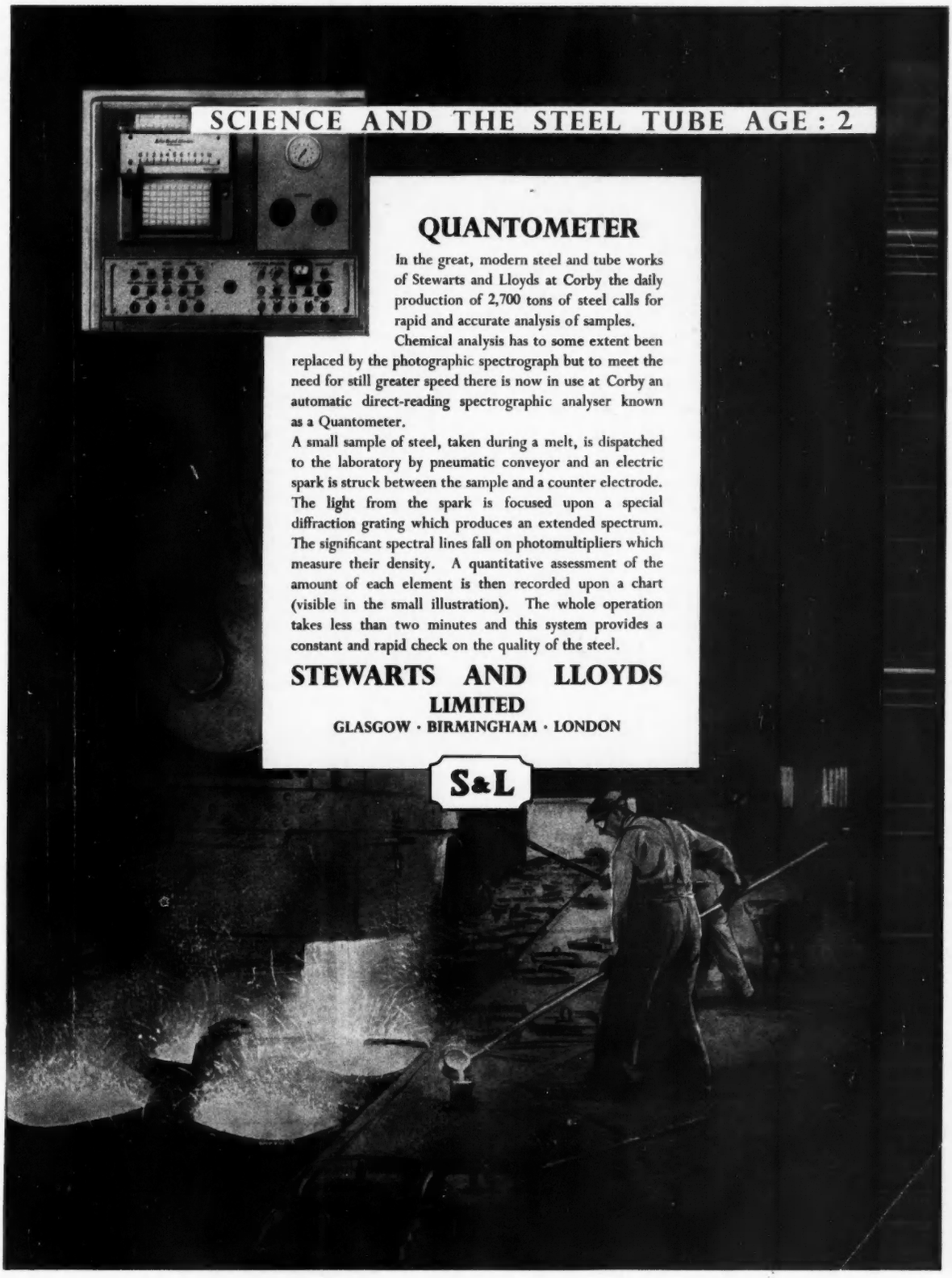
The Engineer

APRIL 19, 1957 — 28 ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

UNIVERSITY OF MICHIGAN
MAY - 1957
ENGINEERING LIBRARY


SCIENCE AND THE STEEL TUBE AGE: 2
QUANTOMETER
In the great, modern steel and tube works of Stewarts and Lloyds at Corby the daily production of 2,700 tons of steel calls for rapid and accurate analysis of samples.
Chemical analysis has to some extent been replaced by the photographic spectrograph but to meet the need for still greater speed there is now in use at Corby an automatic direct-reading spectrographic analyser known as a Quantometer.
A small sample of steel, taken during a melt, is dispatched to the laboratory by pneumatic conveyor and an electric spark is struck between the sample and a counter electrode. The light from the spark is focused upon a special diffraction grating which produces an extended spectrum. The significant spectral lines fall on photomultipliers which measure their density. A quantitative assessment of the amount of each element is then recorded upon a chart (visible in the small illustration). The whole operation takes less than two minutes and this system provides a constant and rapid check on the quality of the steel.
STEWARTS AND LLOYDS
LIMITED
GLASGOW · BIRMINGHAM · LONDON
S&L

no trouble at all...

Unattended in a poorly-ventilated pit at a busy steel rolling mill.

Working 24 hours a day to move 600 tons of hot steel a week and averaging 130,000 stops and starts a month, this Crofts Radiation Worm Reduction Gear conveyor drive has done a vital production job for over six and a half years.

And it goes on and on and on with no trouble at all, the only attention being maintenance of the correct oil level.

You can get first class gears like this from stock for powers up to 140 hp, ratios up to 60 to 1 and 1⅛" to 9" centres

PHONE BRADFORD 65251 EXTENSION 555 FOR IMMEDIATE ACTION

The standard range covers powers up to 450 hp—ask for Publication 521/A

Crofts

(ENGINEERS) LIMITED BRADFORD 3 ENGLAND

Tel : 65251 (20 lines) Grams : 'Crofters Bradford Telex' Telex 51-426

BRANCHES AT : Belfast, Birmingham, Bristol, Cardiff, Dublin, Glasgow, Leeds, Liverpool, London, Manchester, Newcastle, Northampton, Nottingham, Sheffield, Stoke.

THE ENGINEER

VOL. 203 No. 5282 APRIL 19, 1957

CONTENTS

LEADING ARTICLES—
More Steam Locomotive Development 591
Seeing by Radio 592

ARTICLES—
Aircraft Turbines 593
All-Weather Fighter. (Illus.) 618
Arthur Woolf—Master Mechanic ... 600
Construction of Secondary Treatment Plant at the L.C.C.'s Northern Outfall. (Illus.) 610
Factory Equipment Exhibition 593
Gas Turbine Power Station. (Illus.) ... 618
Heavy-Duty Three-Roll Plate Bending Machine. (Illus.) 619
Heavy Express Locomotive Trials on the Western Region. No. II. (Illus.) 594
Hydraulic Ram. (Illus.) 597
Induction Hardening Attachment on an Automatic. (Illus.) 619
Institution of Naval Architects. No. III. 602
Low-Grade Materials for Road Construction 615
Manufacture of Fractional Horsepower Motors. (Illus.) 614
Manufacture of Plastics Patterns for Moulding. (Illus.) 617
Plans for Second Transatlantic Telephone Cable 593
Problems of the Small Utility Car ... 616
Progress of Potters Bar Railway Tunnel. (Illus.) 612
Route of Birmingham to Preston Motorway 593
Technical College Libraries 593
Tractor Testing Techniques 593
Travel in London 601
Wear and Tear. (Illus.)... 605
100 Years Ago... 592

CONTINENTAL SECTION—
French Railways' Modernisation Plan. (Illus.) 621
Large Mobile Transformer. (Illus.) ... 622
Infra-Red Dryer. (Illus.) 622

AMERICAN SECTION—
Experimental Boiling Water Reactor at the Argonne National Laboratory. No. I. (Illus.) 623

LETTERS AND LITERATURE 608

LETTERS TO THE EDITOR—
Advanced Aeronautical Education 608
Reversing Gear 608

LITERATURE 608

NEWS AND NOTES—
British Patent Specifications. (Illus.) ... 627
British Standards Institution... 609
Catalogues and Brochures 628
Forthcoming Engagements 628
Industrial and Labour Notes 620
Launches and Trial Trips 628
Personal and Business 626
Technical Reports 601

MORE STEAM LOCOMOTIVE DEVELOPMENT

In the year of grace 1957 it might seem strange to some of those engaged in the modernisation of British Railways, in the development of nuclear power, or in other modern tendencies, that we should be moved to write not merely upon current steam locomotive practice, but upon development. The closing chapters of steam locomotive history, however, are proving to be not only interesting—nay, fascinating—in themselves, but to us they seem to be pointing an object lesson of considerably wider significance. In the past few years we have had occasion to comment, in terms of warm praise, upon the development work in progress at Swindon since the war. A further milestone in that progress has now been reached in the successful running of express passenger locomotives recently fitted with twin-orifice blast pipes and double chimneys. The results of a series of tests extending over some fifteen months are described in an article we publish elsewhere in this issue, but in studying it the critic might ask: "Is there anything new in the use of twin-orifice blast pipes? Did not Chapelon exploit this principle nearly twenty years ago?" True enough; though there were ample reasons why the device was not adopted earlier on the Great Western Railway. It is, however, not so much the results themselves, as the approach to the problem and the devastatingly critical analysis of all tests, that we find stimulating; but while the modern code of testing practice will no doubt be carried forward into the new age that lies ahead of British Railways, since its application is not confined to steam locomotives, one regards somewhat wistfully the fact that it should have emerged so late in the history of the machine that originally made railways themselves a practical proposition. Until 1939, however, the Great Western Railway had every reason to be satisfied with its locomotive practice, since its fuel costs were by a considerable margin the lowest of any on the British Railways.

The major events in the post-war development of Great Western express locomotives may be briefly recalled. To combat some of the difficulties with inferior coal, a higher degree of superheat was introduced, following to some extent the procedure Sir William Stanier had found necessary after his first introduction of Great Western practice on to the London Midland and Scottish Railway in the "thirties." Simultaneously, on the Swindon stationary testing plant, the practice of testing at constant steam rates was developed and extended to controlled road tests with special trains out on the line. Then came the redraughting of various locomotive types, to provide higher evaporation, and more reliable performance with inferior fuel. The success of these methods with the "King" and "Castle" class 4–6–0s enabled the pre-war standards of high speed running to be largely restored, in 1954, despite conditions that showed a tendency to deteriorate rather than to improve. But a critical analysis of the thermodynamic performance of these 4–6–0 locomotives in comparison with locomotives of other regions showed a rapid decline in efficiency at the higher steam rates, with consequent limitations in power output. Having provided reliable steaming, with economy, in the normal ranges of power output recourse was then made to the twin-orifice blast pipe to enhance the power output, increase the freedom of running, and reduce the coal consumption in conditions of sustained high speed running. Some very fine results have now been achieved, surpassing by a considerable margin the best done in the favourable circumstances existing before World War II. A speed of 110 m.p.h. in ordinary service, the recovery of twenty-one minutes of lost time on the "Cornish Riviera Express," and of the same train taking the ascent from Wellington to Whiteball Tunnel without falling below 60 m.p.h., indicate a new standard of performance from the "King" class engines.

By what precise amount performance has been enhanced has not yet been made public, and in any case comparisons are not always satisfactory or convincing. But there is no doubt that a locomotive of greatly improved all-round capacity has been put into the hands of the running department. To say that it could have been done twenty years ago, when the achievements of Andre Chapelon were so prominently before the railway world, is neither here nor there. The economic consequences of the changes have yet to be seen. In the case of the "Castle" class, in particular, whereas the very efficient running of the 1924 tests was obtained with superheat temperatures of

520 deg. to 530 deg. Fah., the engine with twin-orifice blast pipe recently tested on the " Torbay Express " was reaching temperatures of 730 deg. to 740 deg. Fah. at comparable outputs of power. This, while tending to increase thermal efficiency and promote greater freedom in running, brings disadvantages, too, in maintenance of all parts in contact with the high temperature steam. But any development of the steam locomotive at the present time must be regarded as having no more than a short-time basis, and as such the over-riding need is to give the operating department more power. This, Swindon has most assuredly done. A 4–6–0 locomotive has been evolved in the form of the modified " King " that, up to the limit of hand-firing, seems equal in capacity to any of the " Pacific " type locomotives running elsewhere in this country. The disparity in grate area has been compensated by the improved draughting. While similar attentions to the front-end arrangements of certain " Pacific " locomotives might put them ahead once again, there would seem little point in so doing if the range of hand-firing is thus to be surpassed. There has been in this country for some time a cherished notion that large grate areas and wide fireboxes are essential on the largest express passenger locomotives for dealing with modern fuel conditions, and the Great Western Railway, at the end of World War II, itself had a large " Pacific " locomotive under consideration. But under the dire stress of post-war years, and the need to make-do with existing tools, that notion has now been dispelled—at any rate, so far as modern British running conditions are concerned. If the closing years of steam locomotive history do nothing more than compel a more critical approach, and the establishment of hard facts instead of long-cherished notions, they will indeed have been years well spent.

SEEING BY RADIO

Astronomy is one of the oldest of the sciences, but its devotees, despite some outstanding figures, have not hitherto been especially numerous in the engineering profession. That, however, must now be changing, for we read to-day descriptions of a number of large radio-telescopes recently made or in the making—and especially of the very large one hoped to be completed this year at the Jodrell Bank Observatory near Manchester, which has an aperture of no less than 250ft. The world had grown accustomed to telescopes, great and small, being built up entirely on a basis of optical lenses and mirrors, but here is something quite different, with nothing optical about it at all. It is, in principle, just a short-wave radio receiver, but of very unusual size, running, it may be, into some thousands of tons in total weight though as completely controllable in its movements as any of the earlier types of telescope. Observatories which have, or soon will have, smaller editions of this new type of telescope include Cambridge, Bonn, Sydney, Washington and Harvard, with others designed for Holland and Russia. But in this field of endeavour Manchester at present leads the world.

The new Jodrell Bank telescope and its smaller fellows must, we think, be of special interest to our readers because of their very novelty, the large dimensions they can attain, and not less the important uses to which they can be put. That at Jodrell Bank is being constructed for the University of Manchester and is now almost completed; the cost being met by D.S.I.R. and the Nuffield Foundation. Messrs. Husband and Co. are the engineers in charge of the project; work was was started in 1952 and has been previously described in our pages. Its most striking feature is the steerable paraboloid receiver of no less than 250ft diameter mounted about 170ft above ground. The surface of the paraboloid is a large membrane of sheet metal weighing some 70 tons, and the total weight of the movable steel superstructure is given as some 2000 tons, of which 700 tons are receiving-bowl framework.

It is natural to ask why in the making of observations of the stars there should be any advantage to be gained by replacing the human eye by a radio receiver; and what sort of knowledge is it that is being sought by this extension of observational method? It must be remembered that the human eye is restricted in its choice of wavelength to a range of only about one octave; but radio waves are a very different matter, they have a far greater range of frequency and it is therefore possible to select from the many possible wavelengths the one best capable of penetrating our atmosphere and any interstellar barrier of cosmic dust it may chance to meet. When one looks at the starry sky one gets the impression that one is looking at things—sun, moon, planets and stars—as they now are, but this is by no means the case. One sees them not as they are but as they were. Even the nearest star to us is seen as it was rather over three years ago (for that is the length of time it takes for its light waves to reach the Earth), and the furthest star in our own galaxy, known as the Milky Way, we now see as it was some 100,000 years ago; whilst, in the case of remote galaxies, those observed by optical telescopes are seen as they were no less than a thousand or two thousand million years ago. It happens that during that particular span of years the Universe does not seem to have passed through any remarkably critical period: when, however, the span of years, during which still remoter parts of the Universe can be observed, rises as high as 5000 to 7000 million years a new situation may arise; and with the large radio telescopes this range of time may indeed be reached. In fact, as Sir Edward Appleton put it in a recent lecture: " It looks as though we can see further by radio than by light " !

Careful observation shows the distance from us of other galaxies to be increasing quite rapidly, and the further away they are the more rapid is that speed. Since the various ways for estimating the age of the Universe agree on a figure of not much more than 5000 million years or so, the use of these new instruments may well enable observations to be made of the most distant galaxies during the very days of their birth and infancy; and so, in a sense, the observers may be able to " watch " the evolutionary creation of a part of our Universe actually taking place. The literally minded, or very old-fashioned, may take this to imply that what may be called the " first chapter of Genesis " may thus be " seen " actually taking place! We would not go so far as that, but it may well be agreed that although Adam and Eve have long since gone to their rest, the wily serpent that caused them so much trouble may be, if one judges from the present conditions of affairs in many parts of the world, nearly as active in human affairs as ever he was!

The Engineer
100 Years Ago
(APRIL 17, 1857)

" COLLIERY EXPLOSIONS "

" Next to wars, earthquakes, avalanches, and shipwrecks, colliery explosions appear to hold rank amongst accidents producing the greatest sacrifice of human life. . . . In England, Wales and Scotland, the number of violent deaths caused by mine accidents is in round numbers one thousand every year, and an analysis of the causes of death shows, in round numbers, that one-third of them arise from explosions; one-third from falls of roof; and one third from shaft and other accidents.

" Now the first of these would be wholly prevented by the constant use of lamps, an alteration in the furnace arrangements, and the prohibition to use gunpowder, or else to fire it by electricity when the men are out of the way. The second class of accidents would be prevented by working the mines upon a different system to that usually adopted, but upon one which has been tried and found to answer, and one by which all the coal is obtained, instead of leaving 40, 50, and even 60 per cent of it behind. The third class could be reduced at least one half by careful attention to the pit gear, and the small number of deaths that would occur if these several precautions were taken, would only be such as resulted from gross carelessness. Why, then, are we continually to hear of such frightful occurrences as that at Lundhill? Why are a thousand poor, ignorant, and unfortunate men to be annually sacrificed, when means exist for their safety? The cause may be summed up in one word, that we put no sufficient value upon human life. The new Parliament will surely bestir itself and appoint more Inspectors who will compel such alterations to be made in the working of coal pits as the safety of the men employed and humanity demand."

A Seven Day Journal

Plans for Second Transatlantic Telephone Cable

To provide for the development of telephone and other telecommunication services across the Atlantic, officials of the Governments of Canada and the United Kingdom, together with representatives of Cable and Wireless, Ltd., and the Canadian Overseas Telecommunication Corporation met in Ottawa last week. It may be recalled that, since the first submarine telephone cable between the United Kingdom, Canada and the United States of America was commissioned, in September last, the high quality of the service has led to a great increase in the volume of traffic: for example, the telephone traffic between Canada and the United Kingdom has trebled in six months. The maximum capacity that could be provided when the cable was designed was limited by technical considerations, but sufficient technical progress has now been made to permit the design of cables of increased capacity. With the rapid economic development of Canada, the prospect is that transatlantic telecommunication traffic will continue to grow rapidly and at the recent meeting in Ottawa interim measures were discussed with the object of meeting the immediate needs.

It was agreed in principle by the officials that a new submarine cable, incorporating techniques at present under development, which would accommodate many more circuits than any existing cable of comparable length should be provided as quickly as possible between Canada and the United Kingdom. Accordingly, provisional plans were made for further consideration by the two Governments concerned and for consultations with other Commonwealth countries. It is expected that the new cable could be completed by 1961 as a joint undertaking by Cable and Wireless, Ltd., and the Canadian Overseas Telecommunication Corporation.

Aircraft Turbines

It has been announced that a second Canadian variant of the "Britannia" is to be built; an order has been placed by the Canadian Government for the Canadair CL-44. While the CL-28 "Argus" was modified to turbo-compound engines to give long endurance at low performance on anti-submarine duties, the new transport aircraft will use Bristol "Orion" engines. Many of the jigs, tools and fixtures used for building the CL-28 will be used in the construction of the CL-44, and first deliveries are scheduled for 1959; the aircraft will be the same size as the "Britannia 310." They will be pressurised, unlike the "Argus," and suitable for military passenger or cargo transport, carrying a maximum payload of 45,000 lb, or 120 passengers, considerably greater than civil machines. The cruising speed will be about 400 m.p.h. and the range about 4000 miles. Canadair Limited have been granted the rights to produce and sell in specified areas this version of the "Britannia" for commercial operation.

It has also been announced that the Curtiss-Wright Corporation, of Wood Ridge, Jersey, U.S., is to build a number of Bristol turbines under licence, including one for commercial aircraft, which is expected to provide the thrust for all-weather operation of planned jet aircraft out of existing airports. It will have a lower noise level than current jet transport engines, be superior in fuel consumption and weight, and use "substantially lower" turbine operating temperatures. It seems that this engine cannot use any of the established cycles of operation, such as reheat, but these claims might well be advanced for a ducted fan of a high by-pass ratio, which is an engine, it has been shown, that would be well suited to the high-subsonic airliners being built in U.S.A. Since it is planned to demonstrate the potentialities of this engine in the United States in the near future, it may be inferred that the fan is being driven by an engine similar to one of the present Bristol turbo-prop engines. Curtiss-Wright already holds a licence to build the "Olympus" twin-spool turbo-jet as the J.67.

Tractor Testing Techniques

Last week, a paper describing some of the recent developments in tractor testing techniques at the National Institute of Agricultural Engineering was presented to the Institution of British Agricultural Engineers by Mr. T. C. D. Manby. Mr. Manby began by reviewing the progress of the various tractor testing schemes operated by the National Institute of Agricultural Engineering, and went on to point out that, because of the effective entry of British tractors into world markets, there had been increasing requests for measurements concerning their performance under conditions encountered only overseas.

In formulating a test scheme for investigating overseas conditions, Mr. Manby said, five factors in tractor operation not generally encountered in this country had to be considered. They were: tractive ability under extremely muddy conditions as in the wet cultivation of rice; engine performance at high ambient temperature and humidity; endurance of mechanical components when working in extremely dusty conditions; engine performance at high altitude, and engine starting characteristics under extremely cold conditions. It was thought that something could be done by reproducing the necessary conditions at the N.I.A.E. headquarters at Silsoe, Bedfordshire, to investigate tractor performance in relation to the first three of these factors, and the paper dealt, in detail, with progress made in the determination of tractive ability in mud, and with hot room and dust chamber tests. About engine performance at high altitude, however, Mr. Manby said that the cost and complexity of a suitable altitude chamber was such that it was felt that this aspect of testing could best be done "on the spot" by the recently formed East African testing unit, using a mobile dynamometer truck.

Route of Birmingham to Preston Motorway

The Minister of Transport and Civil Aviation, Mr. Harold Watkinson, has announced the proposed line of the Birmingham-Preston Motorway; the proposed motor road will be 97 miles long. The new road will run from a point on A.41, the Birmingham-Wolverhampton road, in West Bromwich, Staffordshire, in a general northerly direction, passing to the west of Cannock, Stafford, Newcastle-under-Lyne and Stoke-on-Trent; through Cheshire, passing to the east of Sandbach and west of Knutsford to cross the Manchester Ship Canal approximately 1 mile east of Warrington; then through Lancashire to the west of Wigan to join the southern end of the Preston By-pass, now under construction, near Bamber Bridge. It is pointed out that as the road will pass through a heavily industrialised area, the placing of "interchanges" will be more frequent than on the London-Yorkshire motorway.

Factory Equipment Exhibition

The fifth Factory Equipment Exhibition will be opened at Earls Court on Monday, April 29, and be open daily until Saturday, May 4. More than 300 firms will be showing a variety of equipment covering heating, ventilating, steam raising and power plant; trucks and materials handling appliances; storage and office fittings; instruments; tools; protective clothing; welfare and safety equipment, and other factory service requirements. An exhibit of particular note will be the oil fuel centre organised by Shell-Mex and B.P., Ltd., and in which twenty-three oil-burning equipment manufacturers will show representative products.

A number of professional bodies are holding conferences and meetings in conjunction with the exhibition. The British Productivity Council will have a two-day conference on organisation and methods on April 30 and May 1; on May 2 the council is to present four studies in the use of films in industry. At a meeting of the Incorporated Plant Engineers on April 29, Mr. E. C. Stevens will present a paper entitled "An Engineer Looks Forward: Modern Trends in Factory Design and Equipment." The Institute of Materials Handling will hold a two-day conference on May 3 and 4.

Technical College Libraries

The Minister of Education, Lord Hailsham, has addressed a circular to local education authorities stressing the need for well-stocked and well-equipped libraries at technical colleges. The circular says that too many technical colleges are still poorly equipped with libraries, and too few are in charge of qualified librarians. It is suggested that from £500 to £2000, according to the size of college, should be set aside as an annual allowance for the purchase of books and periodicals. The circular urges that a minimum of 3000 volumes should be the stock target, and it adds that "periodicals may be more important even than books, especially to advanced students in technologies which are developing rapidly."

There are several recommendations in the circular about library accommodation and equipment. Libraries, it says, should be easily accessible if students are to be encouraged to use them, and separate reading rooms for books and periodicals may be desirable. Another suggestion is that in a college doing a great deal of advanced work, a small separate room may be required for reading micro-texts, the use of which is likely to increase. A workroom for binding and repairs to books and periodicals should also be provided. The circular states that where these requirements would mean larger libraries than those laid down in Ministry building bulletins, the Minister would be prepared to authorise the extra area. The circular ends with recognition of the fact that the maintenance of an adequate library service is comparatively expensive. But, it says, the service is essential if students are to be trained to seek up-to-date information, to become independent workers rather than passive recipients of lecture notes, and to keep pace with scientific developments after they have passed their examinations.

Heavy Express Locomotive Trials on the Western Region

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E., M.I.Loco.E.

No. II—(*Concluded from page 562, April 12*)

In recent years some important alterations to the draughting arrangements of Western Region express locomotives have been made to enable them to cope with modern fuel conditions. Controlled road tests in 1953 were followed by heavy load tests under service conditions in 1955. As a result, some further alterations have been made to the "King" class locomotives. In this article and a preceding one the author discusses the results of dynamometer car runs in 1955 and 1956.

AT the time of its introduction, in 1927, and throughout the years leading to the outbreak of the second world war, the "King" class was one of the most successful and economical of all first-line express passenger locomotives operating in Great Britain. Certain of the "Pacific" designs introduced by the northern lines were certainly freer running in the very high ranges of speed; but on the Great Western speeds much in excess of 80 m.p.h. are in any case out of the question over the West of England main line, and it was an ability to steam hard and consistently on level and adverse stretches that so distinguished the "Kings." The coal great care had to be exercised in husbanding the water supply. High water consumption is a characteristic of the running of these engines on their own line, and while this feature is largely counteracted by the frequency of water troughs between Euston and Carlisle, in Scotland out-of-course stops for water are not infrequently met with in the ordinary course of travel with these engines. Actually the "City of Bristol" made only one down trip with the "Cornish Riviera Express," but that was a very good one. In the matter of power output, and basic coal consumption, the performance was an almost precise equal of that made by the "King

Fig. 3—"Cornish Riviera Express": London Midland 4–6–2 engine

was not always so good as is sometimes imagined in these times, but the standard of maintenance was high, and although limits of loading were laid down, no difficulty was experienced either by locomotives or men in dealing with considerable increases at times of heavy traffic. Since the reintroduction of the four-hour schedule to Plymouth an attempt was at first made to limit the load to ten coaches, with an additional one slipped at Westbury; so that while the tests of 1955 were carried out with loads of 460 tons to Westbury and 390 tons beyond, in actual practice the service loads during the summer of 1955 were almost invariably 360 and 325 tons respectively. In the winter service of 1955–56 heavier loads were sometimes conveyed at week-ends. Yet in pre-war days the author has known loads up to 520 tons tare taken punctually out to Westbury on the same schedule.

With the London Midland 4–6–2 engine "City of Bristol," tested in May, 1955, very Henry VIII" on March 10, 1955. The overall running times to passing Taunton and Exeter, and to stopping at Newton Abbot were slightly slower, but having regard to the delays experienced en route, there was little in it between the two locomotives. Had the driver been assured of a more frequent replenishment of the tender tank he might have run harder; but in any case the train reached Newton Abbot comfortably ahead of time. As on the March trials, the assistance provided from Newton Abbot to Plymouth was a 4–6–0 of the "Castle" class and the run was completed in exactly four hours. On the following day a punctual run was made with the up express, loaded to twelve coaches throughout, and assisted as far as Newton Abbot, but on the last trial an attempt was made at a maximum output performance; unfortunately, however, water difficulties developed and an out-of-course stop had to be made at Savernake.

In general performance, however, it was noted that the "Duchess" class engine was freer running than the "King," especially at high speeds. At the same time as service trials with the "Cornish Riviera Express" were in progress, the Swindon Locomotive Testing Station was engaged in full-dress trials with the British Railways class "8" "Pacific" locomotive No. 71,000 "Duke of Gloucester"; while the present author would not wish to anticipate the details of the tests that will, no doubt, be the subject of an official bulletin in due course, it was evident that the new locomotive was very fast, and capable of developing a high power output at high speed. With experience of this engine fresh in mind, with experience of the London Midland "City of Bristol," and with recollections of the extreme speed capacity of those Gresley "Pacifics" that are fitted with the double blast pipe and chimney, the Western Region authorities decided to fit up one of the "King" class engines experimentally with a double chimney. This locomotive, the "King Richard III," was put into traffic in the autumn of 1955, and very soon gave evidence of excellent performance. In Table I are given comparable details of the 1955 trial runs, two service runs, and a pre-war maximum load trip. Also included in the table, in view of future developments, are the estimated practicable times at full power output of the diesel-electric locomotive No. 10,203, worked out by the Swindon Locomotive Testing Station, as a result of trials with that locomotive and published in the bulletin commented upon by the present author in THE ENGINEER for May 25, 1956, and June 1, 1956.

Run No. 1, on which the author was on the footplate, was a normal trip with little in the way of checks; as the tare load was below the 360-ton maximum for the South Devon line no assistance was taken from Newton Abbot, and the run to Plymouth was completed non-stop in 1½ min under the scheduled 4 h. On the second trip, with the double-chimney engine, delays due to fog and permanent way work amounted to no less than 21 min; yet, despite this handicap, Plymouth was reached on time. It was remarkable, however, that on this trip the water consumption was actually less than on run No. 1, as follows:—

Engine No.	Net time to Plymouth	Net average speed, m.p.h.	Approximate water consumption, galls.
6026	231	58·6	8150
6015	218½	61·8	7800

The evaporation on these two runs was about 20,000 lb per hour, whereas on the test trip, Run 3, the average actually measured in the dynamometer car was 26,950 lb per hour. Although this could be considered as something near an all-out effort so far as a single fireman is concerned, it is little better than what was expected as a regular performance in maximum loading conditions prior to 1939. The service journey on Run 6, showed fine work throughout. At that time, faster running than nowadays was permitted through Exeter, and this enabled a fast time of 20½ min to be made round the coastal stretch to Newton Abbot; but against this the train was then routed through Westbury and Frome stations, with slacks to 30 m.p.h. at both places. This hindrance more than offsets the advantage taken by the pre-war train west of Exeter so that the net time of 186½ min to Newton Abbot is, in the aggregate, fully comparable. In view of the amount of research put into the "King" class loco-

motives since 1947 it is sometimes asked why, at this late stage in steam locomotive history, the developments now taking place were not embodied earlier. Run No. 6 in this table goes some way to providing the answer ; the original design was, in pre-war conditions, capable of a superb standard of performance without the higher maintenance charges arising from the steam temperatures attained with a high degree of superheat, without the effects of a sharper blast, and the troubles sometimes associated with mechanical lubrication.

In present conditions of working the run of the double-chimney engine, No. 2, is of particular interest. Again the author was privileged to ride on the footplate. The severe delays experienced on this occasion gave an opportunity for the capacity latent in this modernised locomotive to be displayed. At the outset, the driver was aware of three temporary speed restrictions in force, for permanent way work. These were expected to cost about 9 min in running time, and without unduly forcing the pace an attempt was made in the early stages to get some time in hand. With admission rates of 15 per cent cut-off on the level, 15 to 17 per cent on the rising lengths up the Kennet Valley, and 12 per cent after Savernake, 5 min had been gained on passing Patney—81·1 miles from Paddington in 76¾ min. But the incidence of thick fog in the neighbourhood of Westbury led to a delay of 12 min, and instead of passing Castle Cary, as had been hoped, at least 5 min or 6 min early, the train was actually 4½ min late, with all three engineering slacks yet to come. The effect of these slacks was recovered entirely by rapid acceleration and fast hill climbing. The enginemen on this occasion were Driver Newcombe and Fireman Hawker, of Laira shed, Plymouth, with Inspector W. Andress also on the footplate.

Although on some preliminary runs after rebuilding extremely high speeds had been attained, including a maximum of 110 m.p.h., nothing of the kind was attempted on this occasion ; speed was not allowed to exceed 82 m.p.h. at Curry Rivel Junction, near Langport, where the "110" occurred, nor 77 m.p.h. descending from Whiteball summit towards Exeter, where considerably higher speeds are permitted over certain stretches. The performance of the rebuilt engine was all the more impressive on this account. On Runs 1 and 2 in the table, with tare loads of less than 360 tons, and with no assistance taken west of Newton Abbot, the task of the crew is in most respects harder than on journeys when a heavier load is taken from London, and a stop is made for a bank engine. After more than 3 h of running at a high rate of steaming the ascents of the Dainton and Rattery inclines, with a load near the maximum tonnage, provide an excellent test of enginemanship, no less than of locomotive capacity. In neither case can one take a straightforward "charge" at these very steep gradients ; on Dainton the curves are such that speed is limited to 45 m.p.h., both in the approach and on the bank itself, while through Totnes station—at the foot of the Rattery incline—there is a speed limit of 60 m.p.h.

The performance of the two locomotives may be analysed as in Table II.

On Dainton bank both the engines began the climb at about the maximum permitted speed, while through Totnes the speeds were 48 m.p.h. by No. 6026, and 54 m.p.h. by No. 6015. Though both engines climbed well, with their heavy trains, No. 6015, with the double blast pipe and chimney, appeared to have more margin in reserve. The fact that considerably faster work was performed on almost every undelayed section between Paddington and Plymouth, with no appreciable difference in the coal and water consumption from that of No. 6026, suggests an improved front-end performance.

In view of possible future developments on British Railways, the comparison of the actual test results with the estimated possible times with 2000 h.p. diesel-electric locomotive No. 10203 is very interesting. It is evident that a locomotive of this capacity could only just cover maximum present-day requirements if worked throughout at its full capacity. Considerable improvements are to be hoped for in the future, and it would seem desirable to think in terms of a nominal 3000 h.p. as the standard of express passenger motive power.

TABLE II—*Performance of Locomotives Nos.* 6026 *and* 6015

Location	Gradients		Engine 6026	Engine 6015
Dainton Incline, posts 216–218... ...	Between 1 in 57 and 1 in 36... ...	Time, mileposts 216 to 218	3 min 33 sec	2 min 59 sec
		Average speed	33·8 m.p.h.	40·2 m.p.h.
		Minimum speed ...	24½ m.p.h.	26 m.p.h.
		Cut-off range	22–46 per cent	20–32 per cent
Rattery Incline, posts 223½–225½ ...	Between 1 in 71 and 1 in 46... ...	Time, mileposts 223½ to 225½	4 min 24 sec	3 min 31 sec
		Average speed	27·3 m.p.h.	34·2 m.p.h.
		Initial speed	39 m.p.h.	46 m.p.h.
		Minimum speed ...	22 m.p.h.	26 m.p.h.
		Cut-off range	28–45 per cent	24–35 per cent

TABLE I—"*Cornish Riviera Express*"

Run No. ... ... Engine No. ... ... Engine class ... ... Engine variety		Schedule	1 6026 "King" L.S. I.D.	2 6015 "King" D.C. I.D.	3 6013 "King" H.S. I.D.	4 46237 "Duchess" L.M.R.	5 10203 2000 h.p. diesel-electric	6 6028 "King" O.S.
Load, tons tare, to Heywood ...			363	362	460	460	460	514
Miles								
0·0	Paddington	0	0	0	0	0	0	0
9·1	Southall	13	12¼	12¼	12¼	12¼	12¼	12¾
18·5	Slough	19½	21½	20½	21	20	20	21¾
24·2	Maidenhead	24½	26½	25	25¾	24½	25	26½
31·0	Twyford	30½	32½	30½	31½	30½	30¾	32½
36·0	Reading	36	37	35	36	35¼	35¼	36½
53·1	Newbury	54½	55	51½	54½	56½	53	53¾
66·4	Bedwyn	67½	68	63¾	66½	68½	65¾	66½
70·1	Savernake	71½	71¾	67½	70	72½	69¾	70½
81·1	Patney	81½	81½	76½	79¼	81½	79	79¾
94·6	Heywood Road Junction	92	92¼	93	91	91½	89	90¼
Net time to passing Heywood Road			90¼	86¼	87½	89½	89	90¼
Load, tons tare			328	327	393	393	393	409
102·3	Blatchbridge Junction...	99	98¼	105½	97¾	98¼	95	—
115·1	Castle Cary	112	111½	116½	108¾	109	106¼	111¼
140·3	Creech Junction	—	132½	140	128¼	132½	126	—
142·7	Taunton	136	134½	144	130¾	134¾	128	141
153·6	Whiteball Box	—	147½	157½	141½	145¼	138½	155¾
172·2	Cowley Bridge Junction	—	164¾	173¾	157¾	161	153½	171¾
173·5	Exeter	—	166¾	174¾	159¾	162½	155	173
193·7	Newton Abbot	189	189 (pass)	197¾ (pass)	185¾ (stop)	187½ (stop)	178 (stop)	193½ (stop)
	Net time to Newton Abbot	—	185½	176¾	177¾	182	178†	186½‡

* Signal or permanent way checks. † Estimated time at full power. ‡ Route via Westbury and Frome Stations.

Engine varieties : L.S. I.D. = Low superheat : Improved draughting.
D.C. I.D. = Double chimney : Improved draughting.
H.S. I.D. = High superheat : Improved draughting.
O.S. = Original standard design.

Runs 1 and 2 : Service journeys in 1955.
Runs 3 and 4 : Dynamometer car tests in 1955.
Run 5 : Estimated times for locomotive No. 10203
Run 6 : Service journey prior to 1939.

TESTS WITH DOUBLE-CHIMNEY LOCOMOTIVE

In May, 1956, a series of dynamometer car test runs with a double-chimney engine were made in much the same running conditions as those set to the locomotives tested in 1955, except that in general the delays experienced en route were less severe. The running on the West of England road may be summarised as in Table III.

On the basis of running times and speeds none of these runs showed any improvement upon the maximum efforts recorded with engine No. 6013, in March, 1955, and the sustained power output of the run of March 11, 1955, was on no occasion equalled. But whereas the basic coal consumption in pounds per drawbar horsepower hour showed a marked rise, as between the runs of March 10 and 11, the hardest run with the double-chimney engine No. 6002, that on May 31, showed a reduction. As previously the data are quoted for the up "Cornish Riviera" run between Exeter and Reading:

Engine No.	6013	6002
Type	Single blast pipe	Double blast pipe
Load, tons tare	393½	391
Average speed, m.p.h.	64·7	64·7
Firing rate, pounds per hour ...	4210	2800
Net steam rate, pounds per hour ...	29,835	20,800
Average drawbar horsepower ...	1020	799
Coal per drawbar horsepower hour (pounds), exclusive of auxiliaries	4·0	3·5

The effort demanded from the double-chimney engine No. 6002 was considerably less, due to the absence of the heavy east wind that handicapped No. 6013 on the 1955 trial run. So far as coal consumption is concerned, however, the following table shows

the comparative results for the two series of trials—four runs with each engine.

Engine	6013	6002
Coal/drawbar horsepower hour average for series between Paddington and Plymouth in both directions but exclusive of coal theoretically required to raise steam	3·62	3·34
Corresponding water/drawbar horsepower hour	25·8	25·7

The improvement, as would naturally be expected, can be traced to the greater freedom of exhaust in the double blast pipe and chimney. With the double-chimney engine the back pressure, as measured by manometer gauges in the dynamometer car, between the root of the blast pipe cone and the top of the chimney was no more than 1½ lb per square inch, when sustaining 1100 d.h.p. at 85 m.p.h., while the general value of this back pressure was no more than 1 lb per square inch. This shows a remarkable reduction from the back pressures noted with the single-chimney engine No. 6013 at maximum output. The locomotives of this class are proving very fast in ordinary service. Speeds up to 110 m.p.h. have so far been recorded, on descending gradients of 1 in 200 or so, while a maximum of 92 m.p.h. has been sustained on level track with a load of 375 tons behind the tender. On a service run with the "Cornish Riviera Express," one of the modified locomotives was "opened out," for trial purposes, on the ascent to Whiteball Tunnel, and from an initial speed of 80 m.p.h. at Taunton the tunnel was entered at slightly over 60 m.p.h. after 3 miles rising at an average inclination of 1 in 85.

The success achieved with the "King" class locomotives has now been extended to the "Castle" class. This latter series, some 160 engines in all, cover the bulk of the Western Region express passenger services, including the high-speed "Bristolian" express, and it is important that these locomotives be equipped to the best advantage for the years remaining before they are superseded by newer forms of motive power. In July, 1956, accordingly, a series of runs with the dynamometer car were made with engine No. 7018, "Drysllwyn Castle," on the "Torbay Express" between Paddington and Kingswear. This train is not timed so sharply as the "Cornish Riviera" between Paddington and Exeter, due to heavy occupation of the line out to Reading and again west of Taunton. Intermediately, the 106·7 miles between Reading and Taunton are booked to be covered in 102 min, pass to pass. During the test runs engineering work on the line imposed a number of additional restrictions of speed, with the result that on July 24 and 26 the train passed Reading 8¼ min and 9½ min late respectively. The ensuing distance to Taunton was then covered in 92¾ min and 94½ min respectively—the latter time including a further loss of 3½ min from the third engineering slack at Pewsey. Net average speeds over this 106·7 miles were thus 69 m.p.h. and 70·5 m.p.h.

Fig. 5—The "Bristolian" running at 90 m.p.h.; "Castle" class locomotive with twin blast pipe

The load taken was 310 tons tare, including the dynamometer car, and on the faster of the two journeys, that on July 26th, the overall time for the 173·5 miles from Paddington to Exeter was a few seconds under 170 min. Allowing for three engineering slacks, and certain signal delays between Paddington and Reading, the net average speed from start to stop was 66·8 m.p.h. It is interesting to compare this performance with that of the "King," having regard to the difference in nominal tractive effort, boiler pressure, and so on.

	6002	7018
Engine No.		
Date	May 28, 1956	July 26, 1956
Section	Paddington-Taunton	Paddington-Exeter
Net average speed, m.p.h.	65·4	66·8
Average drawbar horsepower overall	825	615
Nominal tractive effort of locomotive, pounds	40,300	31,625

The two locomotives were therefore being worked in approximate proportion to their nominal tractive effort. With the "Castle," a maximum drawbar horsepower of 1050 was noted in the approach to Whiteball Tunnel, at 50 m.p.h. on a 1 in 80 gradient. Correcting for gradient, this would be equivalent to 1475 on level track. The cut-off was then 30 per cent, the back pressure 4·5 lb per square inch, and the superheat temperature 740 deg Fah.

Another notable exposition of the capacity of the locomotive was made between Lavington and Edington, where a speed of 86 m.p.h. was sustained on level track. The following details will be of interest :

Load, tare	310 tons
Load, gross behind the tender	330 tons
Speed sustained on level	86 m.p.h.
Drawbar pull	1·6 tons
Drawbar horsepower	825
Boiler pressure	220 lb/sq. in
Steam chest pressure	205 lb/sq. in
Cut-off	20 per cent
Back pressure	3·8 lb/sq. in
Superheater temperature	730 deg. Fah.

The maximum speed attained on the journey was 88 m.p.h. near Lavington, and again at Curry Rivel Junction, while a further maximum of 84 m.p.h. was reached in the descent from Whiteball Tunnel towards Exeter.

The success of the double-chimney design on the "Castle" class engine No. 7018, in providing a high drawbar horsepower at high speed, may be appreciated further from a

TABLE III—*Tests with Double Chimney Locomotive*

Date	Section	Load, tons tare	Distance, miles	Average speed, m.p.h.		
				Booked	Actual	Net
May 28	Paddington–Taunton (start to stop)	449* 413†	142·7	57·9	64·3	65·4
May 29	Exeter–Paddington (pass to stop)	391	173·5	59·0	59·8	62·4
May 30	Paddington–Exeter (pass to pass)	457* 390†	173·5	63·2	50·9‡	67·6
May 31	Exeter–Paddington (pass to stop)	391	173·5	59·0	63·6	65·1

* Paddington to Heywood Road Junction (94·6 miles). † Heywood Road to Exeter. ‡ Includes exceptional delay of 37min at Patney

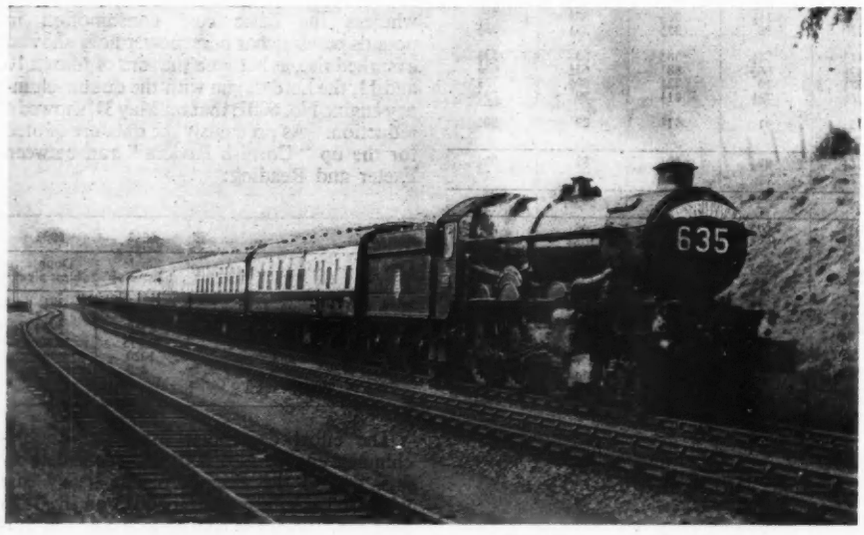


Fig. 4—"Cornish Riviera Express": "King" class locomotive with twin blast pipe

comparison of the above figures with those of a "King," with the improved draughting, but with single orifice blast pipe, as quoted in Mr. S. O. Ell's paper "Developments in Locomotive Testing," read before the Institution of Locomotive Engineers on November 18, 1953.

To produce 825 d.b.h.p. at 85 m.p.h. required a steam rate of 30,000 lb per hour and a coal consumption of more than 4000 lb per hour. The modified "Castle" produced the power under considerably easier conditions of steam. No exact equivalent was to be noted during the trials of the double-chimney "King" in May, 1956, but between Lavington and Edington, at 83 m.p.h. a drawbar horsepower of 1000 was sustained, in hauling a load of 449 tons on level track. According to Mr. Ell's paper, a drawbar horsepower of 1000 at 83 m.p.h. represented about the upper limit of performance of the "King" with the single-orifice blast pipe and improved draughting; it was shown as equivalent to a steam rate of 33,600 lb per hour and the very high coal rate of 5465 lb per hour. On the run of May 28, 1956, the double-chimney engine of No. 6002 produced 1000 d.b.h.p. at 83 m.p.h. in her stride, so to speak, and four days later on the Birmingham road produced 900 d.b.h.p. at 86 m.p.h. in similar circumstances.

Conclusions

Thus in the double-chimney "Kings" and in the "Castle" No. 7018 the notable development of Western Region steam power to meet modern conditions of working continues. Since the trials on the "Torbay Express" the "Castle" has worked in regular service on the "Bristolian" with spectacular results.

On several occasions the 117·6-mile journey from Bristol to Paddington has been completed in less than 100 min. On the fastest run of which details have been authenticated the author was on the footplate, and noted a time of 97 min—an average speed from start to stop of 73 m.p.h., with a gross load behind the tender of 265 tons. The initial stretch of 17·6 miles to Badminton, all adverse, took 22¼ min, after which the next 98 miles were run at an average speed of 82·5 m.p.h. Although this length is slightly favourable to the engine so far as gradients are concerned, there is, intermediately, a restriction to 60 m.p.h. over the junction at Wootton Bassett, and two short sections over which speed is limited to 75 m.p.h. The maximum speed attained was 94 m.p.h. and an average of 89·8 m.p.h. was maintained over the 21·7 miles from Uffington to Goring. Readings of water consumption from the tender gauge showed an average of 28 gallons per mile, or approximately 21,000 lb per hour. The work of the enginemen was all the finer in that the driver W. H. Brown, of Bath Road shed, Bristol, had not his regular fireman with him; the spare man, Phillips, who had never fired this high-speed train before, did remarkably well, and, despite the high rate of evaporation required, kept the engine steaming freely throughout. The keenness of individual drivers and firemen, not only on the full-dress trials, but on service runs with the modified engines, has been, to the author, one of the most impressive and pleasant features of this series of observations, and details of many other runs on the West of England and Bristol trains made available to him by various friends suggest that the enginemen are most appreciative of the enhanced capacity put into the "King" class locomotives by the modified "front-end."

The Hydraulic Ram

By N. G. CALVERT, B.Eng., Ph.D., A.M.I.Mech.E.*

The possible independent variables of a hydraulic ram installation are considered and by certain assumptions their number is reduced to eight. Hence five dimensionless parameters are needed to describe the dependent variables. These are the Reynolds number the Froude number, the Mach number, the head ratio and the coefficient of fluid friction. Each parameter is investigated in turn and it is found that the Reynolds number is ineffective in machines of practical size and that a range exists over which the Mach number has little influence. The Froude number is the criterion defining the possibility of operation and (subject to a satisfactory value for the Froude number), output and efficiency are defined by the head ratio. The optimum external conditions of operation are investigated and the conditions governing model tests are laid down.

THE hydraulic ram is an automatic pumping device which utilises a moderate fall in a water supply in order to raise a fraction of the supply to a greater height. Its mode of operation depends on the utilisation of water hammer and, rather surprisingly, it is a flexible and (under optimum conditions), a highly efficient machine.

A ram installation is shown diagrammatically in Fig. 1. Initially, under the influence of gravity the waste valve "*A*" is open and water under a supply head H_s flows out to waste. As the flow accelerates, the hydraulic drag on the valve "*A*" and the static pressure below "*A*" both increase until the consequent forces overcome the weight of the valve which then begins to close. When once it begins to move both forces increase rapidly and complete closure is extremely rapid. The column of water moving down the drive pipe is thus arrested at the valve "*A*" and there is a consequent rise in pressure in the valve box, which is normally sufficient to open the delivery valve "*B*" and allow some of the water to pass off to the higher level, i.e. to the delivery head h_d. In due course the combined effect of the delivery head, the resilience of the water and of the metal, set up a reverse flow in the drive pipe. Immediately the valve "*B*" closes, the reverse flow tends to overshoot, hence the valve "*A*" falls open again and a new cycle of events begins. A great many variations of design are possible and many different types of valve have been used with success.

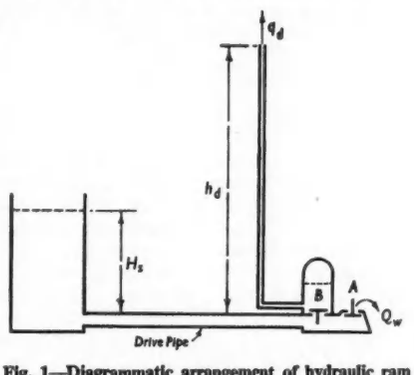


Fig. 1—Diagrammatic arrangement of hydraulic ram installation

The ram has now been used for more than 160 years and, although the field of application may be diminishing with the spread of public water supplies, the author is of the opinion that even in Britain it is not used as widely as its merits justify. This is mainly due to lack of knowledge. The writer personally knows of ideal ram sites where more costly internal combustion engine-driven pumps have been installed. In these cases the owners and their advisers knew nothing of the ram and its capabilities. From a constructional point of view the ram is simple in the extreme but its mode of operation is complex, and there are a great many variables which can, in varying degree, influence its operation. In this investigation the author has sought to simplify the mental picture of ram operation in order that the possibilities and limitations of the ram relative to its site, its adjustments, and its materials of construction should be (qualitatively) immediately apparent. This has been done in the first instance by assumptions as to the influence of particular quantities and after that the methods of dimensional analysis.

There exist two different concepts of ram efficiency. These are attributed respectively to Rankine and D'Aubuisson but both are in fact due to Eytelwein. The D'Aubuisson efficiency considers the ram alone, and (using the nomenclature of Fig. 1) states that the work done in unit time is given by $q_d h_d$ and the energy flowing in to the ram is $(Q_w+q_d)H_s$. Hence the efficiency is $\frac{q_d h_d}{(Q_w+q_d)H_s}$. The Rankine concept considers the plant as a whole and states that the work done is $q_d(h_d-H_s)$ since the water is at an elevation H_s to start with. The net amount of power water is then only Q_w. Hence the efficiency will be $\frac{q_d(h_d-H_s)}{Q_w H_s}$. Of these two the Rankine is the more satisfactory, for the D'Aubuisson admits of an efficiency when there is no net output above the level H_s. The Rankine figure is always the lower but it is only at small head ratios that the difference is significant. The D'Aubuisson concept corresponds to a water-wheel-driven pump which draws from the tail-race while that of Rankine draws from the head-race and so has less lift to perform but has correspondingly less power water to do it with.

When a valve at the end of a pipeline is suddenly closed the greatest possible rise in pressure head is given by $v_c c/g$ where v_c is the velocity in the pipe at closure and c is the acoustic velocity in the pipe (that is the velocity of sound in water modified by the elasticity of the pipe). This is clearly the greatest height to which a ram can possibly lift and it is referred to as the limiting head in the text which follows.

If a ram installation of given geometric form is projected, then provided that it is not operating at its limiting head, the possible independent variables in the installation are:

H_s—The supply head.
h_d—The delivery head.
E—Young's modulus for the ram material.
K—Bulk modulus for the working fluid.
D—A characteristic dimension (taken as the drive pipe diameter).
ρ_m—Density of the construction material.

* Lecturer in Mechanical Engineering in the University of Liverpool.

ρ_w—Density of working fluid.
ν—Kinematic viscosity of the working fluid.
g—Acceleration due to gravity.
f—Coefficient of fluid friction for the interior surfaces.

The assumption of geometric similarity precludes any variation in the valve stroke, hence this is not an independent variable. When all the above are fixed then the following dependent variables are fixed also :

v_c—The velocity in the drive pipe just sufficient to cause the waste valve to close.
c—The acoustic velocity in the drive pipe.
q_d—The delivery quantity per unit time.
Q_w—The waste quantity per unit time.
$\sim$—The beat frequency.
The quantities compounded of the above, the power and the efficiency.

It is now assumed that the two elastic moduli only influence the acoustic velocity c and that the liquid and metal densities only influence the closing velocity, v_c.

These assumptions reduce the independent variables from ten to eight (H_s, h_d, D, c, v_c, g, f), and the dependent variables from five to three (q_d, Q_w, $\sim$). The independent variables can now be grouped into five dimensionless parameters.

$$\frac{v_c D}{\sim}, \quad \frac{\sqrt{2gH}}{v_c}, \quad \frac{v_c}{c}, \quad \frac{h_d}{H_s}, \quad f.$$

The first three are Reynolds number, Froude's number, and Mach's number respectively, and they are referred to as R, F and M in the text which follows. The fourth is the head ratio and the fifth is the coefficient of fluid friction for the interior surfaces.

When the ram operates at its limiting head, then h_d becomes $\frac{v_c c}{g}$ and ceases to be an independent variable. q_d then becomes zero and the head ratio is no longer needed to define the remaining dependent variables. This investigation is concerned mainly with the state where the ram has a definite delivery quantity q_d and where h_d is still an independent variable.

The dependent variables can now be expressed in dimensionless form, thus :

$$\frac{q_d}{w v_c D^2} = \phi_1(R, F, M, h_d/H_s, f),$$

$$\frac{Q_w}{w v_c D^2} = \phi_2(R, F, M, h_d/H_s, f),$$

$$\frac{\sim D}{v_c} = \phi_3(R, F, M, h_d/H_s, f).$$

Similar expressions could also be written for the compound variables, power and efficiency.

The Experimental Attack

Given the five parameters, R, F, M, h_d/H_s, f, the aim of the experiments was to vary one at a time all the others being held constant. This was not strictly possible in every case. Tests for the effect of h_d/H_s and F can be carried out on a single ram adjusted for one value of v_c provided that both supply and delivery heads can be varied. To test for Reynolds number effects a geometrically similar ram installation must be available, or the operating fluid must be changed. The first is the simpler alternative. Tests for the effects of f and M are more difficult and they are discussed later.

Tests have been carried out on a 2½in ram of orthodox construction which was available in the laboratory. The author also built two experimental rams (as near as possible geometrically similar) of 1½in by 20ft drive pipe dimensions and ¾in by 10ft respectively. These drive pipe lengths are not necessarily the optimum values. The L/D ratio for the drive pipe of the 2½in ram was the same as that of the experimental rams but the ram body itself was different. Tests were carried out with supply heads ranging from 3in to 16ft and delivery heads up to 320ft. The conclusions in this paper are based on some 500 trials, in each of which h_d, q_d, H_s, Q_w, and $\sim$, were all measured. Water quantities were measured by weight and time methods, heads by direct lift or pressure gauge and beat frequencies by an electric counter.

The object of the research was to determine trends rather than absolute values. It was believed that general conclusions might be drawn which would be true for any ram, but the exact shape of the curves and the magnitude of the numerical values would be expected to vary according to the particular design. Only the three basic dependent variables have been plotted. Compound variables such as power and efficiency could, of course, be obtained in any particular case. Conclusions as to the effect of *F.M.* and h_d/H_s have been supported by a great many experiments. To avoid repetition only a few representative sets of curves are shown. The experimental evidence regarding R and f is much more limited. This is made clear in the appropriate parts of the text.

The Influence of the Head Ratio and the Froude Number

These two parameters can very well be studied together, since both can be varied by varying the supply and delivery heads imposed on the ram without varying any of the ram adjustments. These parameters have been investigated on the 1½in and the 2½in rams.

In a typical trial the supply head was kept constant and the delivery head was increased in steps of 10ft until delivery ceased or became insignificantly small. The trial was then repeated at another supply head. Such trials can be represented by families of curves on fields whose abscissæ are delivery head and whose ordinates are Q_w, q_d and $\sim$ respectively. Two such trials are illustrated in Fig. 2, (*a*) and (*b*). Information from many such trials can be replotted to show the effect of head ratio, h_d/H_s and Froude's number F when these parameters alone are varied.

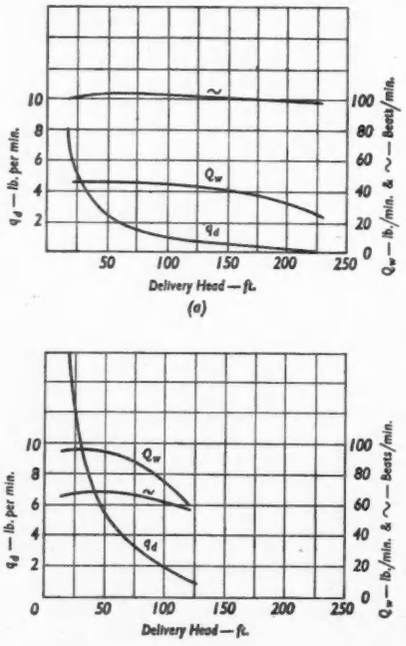


Fig. 2—(*a*) Characteristic curves for 1½in ram under a supply head of 4ft. $F=9{\cdot}2$. (*b*) for 2½in ram under a supply head of 4ft. $F=9{\cdot}2$

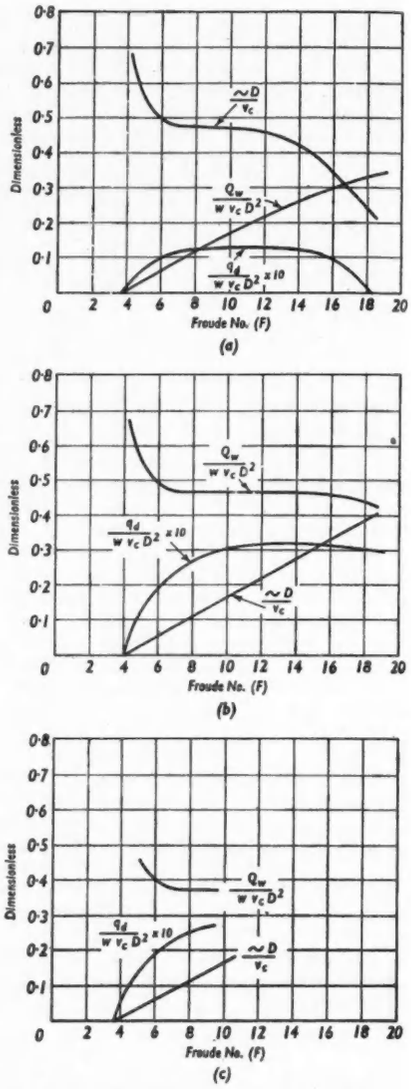


Fig. 3—Effect of Froude number. (*a*) $F=\sqrt{2g\,H_s}/v_c$. 1½in ram. Head ratio=20. (*b*) $F=\sqrt{2g\,H_s}/v_c$. 1½in ram. Head ratio=10. (*c*) on 2½in ram. Head ratio=10

The effect of F can well be studied first. If q_d, Q_w and $\sim$ are plotted for a fixed head ratio as ordinate against F as abscissa, then curves such as those of Fig. 3 result.

These graphs are drawn for constant head ratios of 20 and 10 for the 1½in ram and a ratio of 20 for the 2½in ram, v_c being 1·74ft per second in each case. Following first the q_d curve for the 1½in ram at $h_d/H_s=20$ it is seen that the ram does not start until the F number becomes 3·85. Increasing F now rapidly increases the delivery quantity and diminishes the waste until at $F=7$ fairly stable conditions prevail. Further increase in F has only a small effect until at $F=14$ both waste and delivery begin to diminish until at $F=18{\cdot}5$ delivery ceases. A reduced waste continues. The ram has now degenerated into a vibrator and has ceased to be a pump. The beat frequency increases steadily with F throughout the whole range. At lower head ratios the curves continue, with much the same form, into a region of greater F. Very significant is the fact that over an appreciable range F has little influence on q_d or Q_w. Over this range the performance of a ram on a fixed adjustment becomes a function mainly

of the head ratio, and curves of q_d and Q_w (but not of ~) against head ratio all tend to coalesce (Fig. 4). This fact is undoubtedly the basis of formulæ of the Eytelwein type

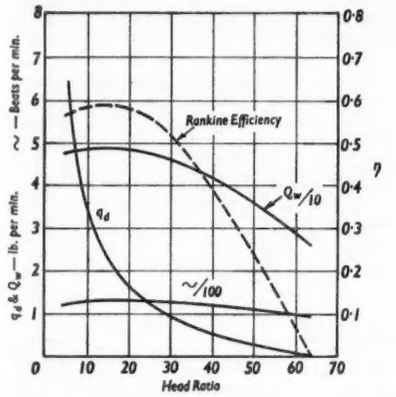


Fig. 4—Effect of head ratio on 1½in ram. $F=9{\cdot}2$

which are discussed later. Low values of F imply high waste and low delivery, conditions to be avoided.

Effect of Reynolds Number R

This parameter was investigated by varying the representative length D, keeping the velocity and viscosity unchanged. To this end, after a considerable amount of work had been done on the 1½in ram, a ¾in ram was built, using the same kind of materials. It was made as nearly as possible geometrically similar. The valve loading was adjusted until it had the same value of v_c.

When this ram was tested under the same heads as the 1½in ram it was found that the delivery and waste quantities were one-quarter those of the 1½in ram and that the beat frequency was twice as great. This was checked at about thirty corresponding points. These results imply independence of q_d, Q_w and ~ (Fig. 5) (when expressed in dimensionless form) of the Reynolds number R. By

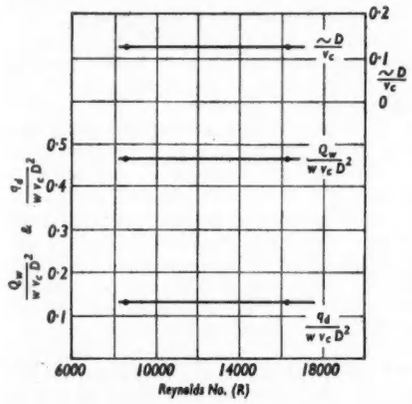


Fig. 5—Effect of Reynolds number R at $F=8{\cdot}1$. Head ratio=20

comparison with other fluid phenomena, if R has little influence over a certain range of size (fixed velocity and viscosity), then it is likely to have even less influence if the size is increased. Hence, the author's conclusion is that in machines of practical size the effect of changes in the R value can be ignored. This conclusion, expressed in different terms, was also reached by Eytelwein 153 years ago.

The Effect of the Friction Coefficient f

This coefficient has been changed experimentally by the substitution of a copper for the steel drive pipe on the 1½in ram. At the same time, the value of v_c was reduced in proportion to the consequent reduction in the acoustic velocity so as to keep the M value the same. The f values (determined for steady flow at the closing velocity v_c) were 0·01 and 0·007 for the steel and copper drive pipes respectively. The ram body was the same in each case. The effect of the change is shown in Fig. 6. There is little, if any, change in the dimensionless waste or frequency, but a very marked increase in delivery when f is reduced between these limits. The delivery quantity increased by one-quarter at a head ratio of 10 and by one-third at a head ratio of 30. There is no evidence as to the shape of the curve in between. These experiments serve to underline the well-established practical conclusion that ram pipes and passages should be as smooth and fair as possible.

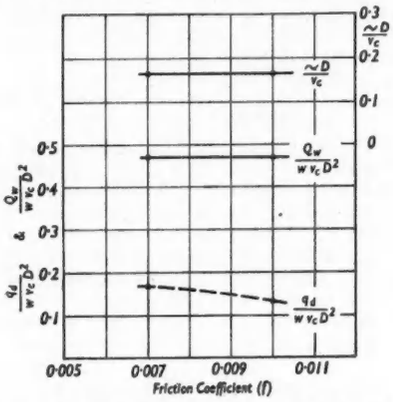


Fig. 6—Effect of friction coefficient f on 1½in ram. Head ratio=20. $F=10$

Effect of the Mach Number M

If all the other parameters are to be held constant and if the fluid is to remain unchanged, then M can only be varied by varying the elasticity, i.e. the wall thickness, of the pipe. This is very limited experimentally and has not been attempted. Alternatively, the pipe material may be varied, but in general this would vary the friction properties also. However, something can be done over a limited range by varying v_c and the supply head in such proportions as to keep F constant. This assumes no effects due to the change in R. Increasing v_c soon leads to experimental difficulties for as v_c is increased, the supply head must increase as the square of v_c if F is to remain constant. Since the head ratio h_d/H_s is constant also, h_d shortly becomes excessive and the ram action becomes violent. v_c is best varied by varying the valve loading. To alter v_c by altering the valve travel would introduce a change in the geometry of the installation. (There is, however, some evidence mentioned later which suggests that such small changes in the geometry are not important provided v_c is the same.)

In the curves of Fig. 7*a* the first four points were obtained by varying v_c from 1ft to 4ft per second and the last point was found by substituting a rubber-canvas hose for the steel drive pipe. This hose had friction properties little different from those of the steel, but the acoustic velocity was 750ft per second, compared with 4600ft per second for the steel. The acoustic velocity was obtained in each case by finding the maximum lift of the ram and equating it to $v_c c/g$. The value for steel was checked by calculation and found to agree within about 4 per cent. Fig. 7*a* shows that the M value has little effect on ram performance except when the limiting head is approached. This is not likely to happen under ordinary operating conditions when the ordinary materials of construction are used.

With ordinary materials of construction there is little scope for change in the value of c. The upper limit of 4700ft per second occurs when the pipe is completely rigid. This is not much different from that of 4600ft per second in the thick walled steel pipe used in most of the experiments. Substituting a thin walled copper pipe reduced c to 4200ft per second. The range of materials at present available gives little freedom of choice. If a major ram installation is ever contemplated it has been suggested that reinforced concrete might be used for the drive pipe. As pointed out by Kroll (1951) the low modulus of this material would have to be kept in mind to ensure that the M value was not such as to spoil the performance. For a small installation (apart from first cost), a copper drive pipe with its moderate modulus, low friction and freedom from incrustation or corrosion, is perhaps the nearest approach to perfection. Fig. 7*b* shows three supporting tests (at v_c= 1·5, 1·75 and 2.0ft per second respectively) on the 2½in ram. In this case it was not convenient to vary the valve loading and v_c was changed by varying the valve stroke. (This was justified by tests on the 1½in ram where both valve loading and stroke could be varied. In particular, a reduction of the valve travel by 25 per cent and an increase in the valve loading such that v_c was unchanged did not appreciably affect the properties of the ram.)

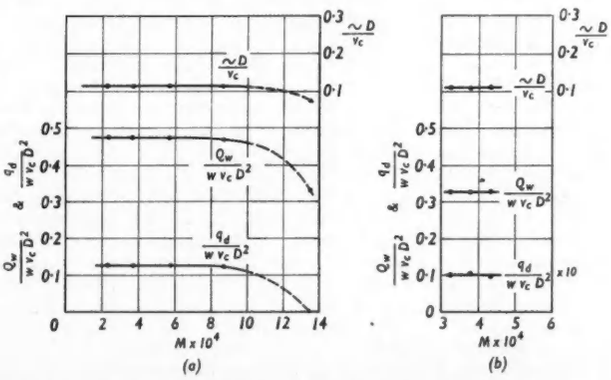


Fig. 7—Effect of Mach number. (a) $M=v_c/C$ at head ratio=20. $F=8$ (b) $M=v_c/C$ at $h_d/H_s=20$ and $F=8$

Model Testing

The conditions governing a model test follow from the Reynolds number having no significant effect. If the model and the prototype are made of the same materials, work under the same heads and have the same value of v_c, then the quantities, delivered and wasted of the prototype will be those of the model multiplied by the square of the size ratio and the efficiencies will be the same. The beat frequency of the prototype will be that of the model divided by the size ratio. Model tests could well be performed before a ram of even moderate size is installed. Carried out on, say, a 1in machine such things as the most economical length of drive pipe and the optimum valve setting could readily

be ascertained and the prototype results predicted as above. The test equipment required is extremely simple being no more than a bucket, spring balance and pressure gauge.

Comment on Eytelwein's Formula

For a single ram, at a single adjustment, M and f are constant. R is ineffective in machines of practical size and, over a considerable range, F has little influence. These facts are undoubtedly what lead to formulæ of the Eytelwein type which attempt to describe ram action in terms of head ratio alone. They also led the author to investigate Eytelwein's original papers and to come to the conclusion that Eytelwein's work had been unjustly neglected and even maligned by later writers.

The hydraulic ram in its present form was the subject of a patent by Joseph Montgolfier in 1797. The following year Boulton and Watt made an abortive attempt to commence manufacture in England. In fact, manufacture did not begin here until 1820 when the Montgolfier patents were assigned to Josiah Easton. In 1803 Professor Eytelwein of Berlin acquired a Montgolfier ram, and after observing its weak points he built two rams of his own (1in and 2in drive pipe diameter respectively). Dickenson (1936) states that Eytelwein's experiments were carried out on a Montgolfier ram. This is not correct. Eytelwein's rams were geometrically similar and were fully fitted for experimental work (i.e. alternative types of valve, adjustable stroke and loading, resilient seats, variable drive pipe lengths, &c.). On these he carried out a series of tests, probably the most comprehensive even to date, (Eytelwein 1803). The two concepts of ram efficiency nowadays attributed respectively to D'Aubuisson and Rankine were both defined by Eytelwein, who showed that the Rankine value must always be the lower. In each case he drew the corresponding water-wheel-pump analogy. Eytelwein used the technique of fine air bubbles in a glass tube to visualise fluid flow, built a form of mechanical indicator to record valve movements, and proposed a compound ram for large head ratios. In particular, he pointed out, with firm qualifications as to range and conditions, that certain of his test results could be represented by an empirical formula of the type, Efficiency $= A - B\sqrt{h_d/H_s}$, where A and B are constants. Removed from its context and without Eytelwein's qualifications it has been quoted in handbooks ever since, and not surprisingly, often found wanting.

Conclusions

The Froude number defines the limits between which ram operation is possible and it is also the principal criterion of the beat frequency.

Reynolds number has no significant effect, hence the conditions for model testing are extremely simple.

Given a satisfactory value for the Froude number, then the head ratio becomes the criterion of efficiency and performance. The efficiency tends to fall at high head ratios, due to excessive shock losses and at low head ratios due to restriction of the delivery valve.

Mach's number is not likely to exert a significant influence unless extreme materials (e.g. rubber) are used in the construction.

The effect of fluid friction is such that it is worth adopting all reasonable means to keep the coefficient low.

The wide range of the operating conditions under which M, R and F have little influence on the performance makes the ram one of the most tractable and adaptable of all machines.

There are two sets of factors which influence the power and efficiency of a ram installation. The first set includes factors intrinsic to the design, the fairness of the waterways, and the geometric proportions of the parts. The second set includes the imposed conditions under which the ram must work and the adjustments which can be made to meet these conditions. It is with this second set that this investigation is mainly concerned. External factors which tend towards high efficiency are :—

a—A low head ratio
b=A sufficient value for F.
Also a high output requires a high value for v_c.

Normally when v_s is increased, then F is diminished : the result is a compromise. The author's experience with three different rams suggests an optimum value for F of about 7.

Conditions are most favourable when the supply head is high and the head ratio low.

It is interesting to note that (so far as the author is aware) the highest efficiency claimed for a ram installation is for that at Seattle waterworks, which, according to Carver (1919), operates at 91 per cent. This plant uses a supply head of 50ft and a head ratio of three.

Acknowledgments

The author wishes to thank Professor W. J. Kearton, D.Eng., M.I.Mech.E., for permission to carry out the work in the Mechanical Engineering Laboratories in the University of Liverpool, and Professor F. W. Walbank, M.A., F.B.A., Professor of Ancient History in the University of Liverpool, for the translation of Eytelwein's original works.

References

Kroll, J., 1951, *Proc I.Mech.E.*, Vol. 165, page 53, "The Automatic Hydraulic Ram."
Dickenson, H. W., 1936, *Transactions of the Newcomen Society*, Vol. XVII., page 73, "Early Years of the Hydraulic Ram."
Eytelwein, J. A., 1805, *Bermerkungen uber die Wirkung und Vorthellhafte Anwendung des Stosshebers* (Berlin).
Carver, T. H., 1918, *Eng. News Record*, Vol. 80, "Hydraulic Rams Show 91 Per Cent Efficiency."

Arthur Woolf—Master Mechanic

By T. R. HARRIS

RECENTLY some hitherto unpublished material, dealing with the life and labours of Arthur Woolf, during his sojourn in Cornwall after his return from London, has been discovered.

This material is embedded in manuscript books of the old Hayle Foundry of Henry Harvey. These consist of duplicate letter books, cash books, stock books and stem or wages books.

Some original letters of Arthur Woolf and others, written to Henry Harvey, also contain interesting information.

On Woolf's return to Cornwall he felt the need of a foundry in the county, capable of producing the larger and heavier castings required for the engines he was building, and contemplated the erection of one himself.

He was, however, persuaded to abandon that idea and, instead, to give the small foundry at Hayle the benefit of his experience. Consequently in 1816 he became consultant at Hayle and under his direction a new foundry was built capable of producing large cylinders and engine beams.[1]

Stock books of 1816, 1826 and 1836 give details of machine tools at the foundry, and the impact of Woolf on the concern is clearly seen from a comparison of the stock books at these ten-yearly intervals.

Early in 1824, Henry Harvey and Arthur Woolf were at Birmingham and South Wales[2] presumably visiting the Eagle Foundry of William Brunton and the Neath Abbey Iron Works of Joseph T. Price prior to further extensions to the foundry at Hayle. The stock books clearly indicate the change over from a foundry, in which there were a few auxiliary tools to enable an occasional cylinder to be bored, to a well-equipped "factory" capable of producing high-class engines. In 1816 a sum of £150 was entered for "Sundry tools" and as there is no separate entry for any boring apparatus or lathe it is presumed that this sum included such machines, for it is known that a boring mill was a part of the establishment prior to 1794 and that there were a number of small hand lathes in the works in 1801.

Many of the new tools were made at the works as and when practicable. In 1816 there is an entry for "the body of a holing engine" which was completed by the time of the 1819 stock taking. This holing engine was for making the necessary rivet holes in boiler plates.

The stock of 1820 includes the items "£1000 for new machinery in the Mill" and "sundry parts for turning lathe" indicating that Woolf was busy equipping the plant with new tools which were being made at Hayle. During the next two years the figures for "New machinery in the mill" increases to £1200 and £2000.

In 1826 the machinery is listed in detail for the first time. This includes "Boring and Turning Apparatus in the Boring Mill, two Cranes and Winches in the Boring Mill, Large lathe (No. 1) in under fitting up shop, No. 2 lathe, Nos. 3 and 4 mandrel lathes, No. 5 centre lathe, Nos. 5 and 6 mandrel lathes, No. 8 face-plate lathe, No. 9 foot lathe, drilling machine in fitting up shop," &c.

Three steam engines of 8in, 16in and 18in diameter cylinders were in use in the works for driving this machinery.

In addition to the list of machinery, reference to sundry parts of machine tools were to be found in other sections of the inventory of stock, as "one cast iron boring bar 15in diameter, 17ft 2in long, Cast steel cutters, chisel boring bits and Universal Joint for boring cylinders."

From the foregoing it will be seen that a much improved boring and turning apparatus has been installed together with a variety of lathes.

The Journal of Simon Goodrich who visited Hayle in 1825 records this visit to "the extensive iron foundry and steam engine manufactory" when he was "surprised to see the extent of this work and the number of Tools and means for doing work considering what is doing in other parts of the country . . . Mr. Woolf employs this work in making his Engines."

Woolf did not, however, devote the whole of his time to the foundry, but still acted as engineer to several mines in the county and was often engaged on work for other parts of the country or abroad.

For example in July 1823, he was "in the North"[3] and his return was necessary before an inquiry respecting a 30in cylinder

engine could be answered. Then again, in 1824, Woolf designed and superintended the making of a large quantity of mining machinery for John Taylor for use in Mexico.

In 1823, Woolf contracted for two 70in cylinder engines for Wheal Sparron Mine. One of these engines was to be made at Neath and the other at Hayle. Woolf was to forward the drawings to Neath " as speedily as possible " and was prepared to follow them himself " if by so doing it would facilitate completion."

Joseph Lowe, acting on behalf of the Anglo Mexican Company, was in treaty with Harvey in 1827, relative to a winding engine for Mexico. A number of points were discussed before the design of the machinery was finally settled. Woolf was consulted about the cages and was of opinion " they had better be horizontal—being more convenient for laying on the rope from the shaft without a twist and many other reasons confirmed by practice."

It was also stated that the estimate did not include any steam case, but " Mr. Woolf thinks it very desirable." Woolf proposed an alteration " in the velocity of the buckets and to have larger buckets." Later he submitted a sketch of the form of boiler which had been adopted generally in Cornwall for the previous fifteen years, with the remark " the saving in coals may be considered 50 per cent."

The Anglo Mexican Company subsequently desired that the engine be portable and it was suggested that the main beam be dispensed with and side rods, together with a number of cranks, be substituted. Harvey wrote the company that to discuss these alterations " Mr. Woolf, if you desire and which we should certainly recommend, would go to London, provided you would not object to paying his expenses."

In January, 1829, Wm. Clemence, manager of a mine in North Wales, applied to Harvey for an engine. In his letter he expressed a wish that Mr. Woolf should design and inspect the engine. " I prefer," wrote Clemence, " Mr. Woolf to any other engineer in the world. . . . If Mr. Woolf thinks 9ft (stroke) is preferable to a 10ft I will be guided by his opinion."[4]

During the same year Woolf was consulting engineer to a scheme for a swing bridge at Penryn (Cornwall). The bridge was erected co-jointly by the Hayle and Perran foundries, and at first gave some trouble because of the settling of the masonry, thereby causing excessive friction of the spill in the socket. To overcome this objection, Richard Hosken, of the Perran Foundry, succeeded in getting oil to the bottom of the spill of the bridge and found that it eased the movement considerably. He feared, however, that every tide would wash it out or dislodge it, and was of opinion that this could be remedied by a stuffing box as he had proposed to Mr. Woolf or, more effectually, by " Mr. Woolf's plan for a trough with mercury."[5]

In 1829, Henry Harvey was engaged in a lawsuit with his neighbours and rivals in trade, the Cornish Copper Company, over the ownership of certain quays in the harbour of Hayle. Woolf was of great help in procuring and presenting evidence which won the suit for Harvey.

Woolf's latter years in Cornwall were dogged by ill-health, the loss of his wife and financial troubles.

Although he was frequently indisposed and could not attend the foundry at Hayle, he was continually devising new engines and improved mechanisms. Thus we find him informing Harvey on March 31, 1829, " I was in hopes that I should have been at Hayle this week, but I have a fresh attack come on yesterday that it has banished all hope for the present. I should like to know how the engine for Wales is getting on. I have been contriving a portable engine which I think you will approve of. I wish you would order Saml. Hocking to come to Camborne for 2 or 3 days to get the drawings done . . ."[6]

In June, 1831, he was again confined to his home. The cause of this was " a violent complaint in the chest and head."[7] In the next month Woolf informed Harvey that the time of his next visit would be uncertain " on account of my health, which at present is very precarious and I am advised to try a change of air. I believe I shall leave Camborne on Monday."[8]

Twelve months earlier Captain King, R.N., of Falmouth, was anxious to try higher pressure steam in one of the Government vessels at that port and inquired from Henry Harvey the price and particulars of the necessary engines and boilers. In his reply, Harvey stated that before making an offer he desired to consult Mr. Woolf, who was " at present suffering under a severe domestic affliction."

The nature of this was communicated to Harvey in a note from Woolf which told of " the sudden death of my poor wife which happened soon after my return home last evening, the shock has been almost too great to bear."[9] Woolf also asked for some assistance as he had no other resources.

Like most Cornishmen of that period Woolf invested in local mines and often found that instead of receiving a good dividend he was required to meet the demand for " calls," and thus he occasionally found himself financially embarrassed.

One such calamity overtook him in November, 1830. On this occasion Harvey contacted R. B. Follet enclosing a copy of a writ that had been served on Woolf, with a request that Follet should appear for Woolf.[10] The suit dragged on and on June 29, 1831, Woolf wrote Harvey " I have received to-day a Lawyer's bill from London, payment for a debt and costs amounting to £21 17s., which if not remitted immediately I shall be arrested. If you will have the goodness to send me a bill for the amount by bearer so that I can remit by to-morrow you will greatly oblige."[11]

In January, 1832, Woolf was served with a writ he did not expect and was again in communication with Harvey asking for a loan of about £20.[12] Some months later Harvey informed Follet " we see very little of Mr. Woolf, but we understand that he intends converting all his available property into cash and leave these parts for some time and by the by ultimately to take the benefit of the Insolvent Act."[13]

By June Mr. Woolf had " left Cornwall with a view of placing himself in the King's Bench." For a while he was at Bristol, but by November he had left for Jersey.[14]

REFERENCES

[1] Entry in cash book, March 31, 1824: " Pd A. Woolf engineer for his attention to the interests of this Co. 8 years to this day. £400." Entry in stem (or wages) book, November 14, 1816, gave details of " building the walls of a new foundry."
[2] Entry in cash book, March 31, 1824.
[3] Letter of Henry Harvey, July 23, 1823.
[4] Letter of Wm. Clemence, January 6, 1829.
[5] Letter of Wm. Wilson, of Perran Foundry, March 13, 1829.
[6] Letter of Arthur Woolf, March 31, 1829.
[7] Letter of Arthur Woolf, June 29, 1831.
[8] Letter of Arthur Woolf, July 15, 1831.
[9] Letter of Arthur Woolf, June 11, 1830.
[10] Letter of Henry Harvey, November 1, 1830.
[11] Letter of Arthur Woolf, June 29, 1831.
[12] Letter of Arthur Woolf, January 12, 1832.
[13] Letter of Henry Harvey, May 26, 1832.
[14] Letter from Jones and Smith, Bristol, November 13, 1832.

Travel in London

A REPORT entitled " London Travel Survey, 1954," containing the results of a survey executed by the Social Survey (Central Office of Information) on behalf of the Road Research Laboratory of the Department of Scientific and Industrial Research, the British Transport Commission and the London Transport Executive, has been published this week. The actual survey was made in the spring of 1954, and the information obtained relates mainly to the winter season and to travel during school term time. Comparison between the 1954 and the 1949 travel surveys is limited, says the report, because the 1949 survey only covered journeys made by public transport, and, moreover, only those journeys made " regularly," whilst the latest survey covered both regular and casual journeys. The Greater London region, as used by the Registrar-General, with the addition of a few fringe boroughs, formed the main survey area, an area broadly corresponding to the sphere of operations of London Transport's Central Road Services. Six focal towns served by London Transport's green country buses were also included ; they were Dartford, Reigate, Watford, St. Albans, Grays and Hemel Hempstead.

The survey, which involved interviewing nearly 17,000 people, was made so as to provide comprehensive information about travel into and out of the central area of London, and nearly twenty pages of the report are devoted to detailed tables and diagrams analysing the findings of the survey. The first five chapters of the booklet deal with the travel habits of the people of Greater London, and Chapter 6 deals entirely with the country towns. The survey revealed convincing evidence of the lack of staggering of work hours over London as a whole, and with regard to finishing times, the report points out, there appears to have been a deterioration since the 1949 survey. Figures show that 61 per cent of workers in the central area of London began work at 8.0, 9.0 and 9.30 a.m., whilst 65 per cent of them finished at 5.0, 5.30 and 6.0 p.m.

Technical Reports

Special Study of Domestic Heating in the United Kingdom. Vols. I and II. The Institute of Fuel, 18, Devonshire Street, W.1. Price 31s. 6d.—The forty-five papers submitted to the domestic heating conference of The Institute of Fuel, held in May last, are widely accepted as providing a compendium of information on domestic heating that will often be consulted by architects, local authorities and technical people in this field. The papers were contained in Volume I of the transactions published in advance of the conference. Volume II has just been published, completing the transactions. The second volume contains some important papers that arrived too late for inclusion in Volume I as well as the full record of the contributions to the discussion, replies and summing-up of the proceedings at the conference.

Advances in Steel Technology in 1955. Vol. I. Prepared by the Secretariat of the Economic Commission for Europe. Geneva : United Nations. Available from Sales Section of the European Office of the United Nations, Geneva, Switzerland, or from H.M.S.O., P.O. Box 569, London, S.E.1. Price 22s. 6d.—For the fourth consecutive year, the Secretariat presents a report on recent advances in steel technology. With the present report, the committee felt that it would be preferable for the subjects to be treated to be selected by the countries taking part in the committee's work, and for the review to be based on contributions by national experts, the Secretariat's part being mainly one of selecting and editing the information supplied. The first part of the report is concerned with basic raw materials, such as coke and iron ore ; certain aspects of production are then examined. The third section deals with the production of steel, while the fourth examines various problems arising in the finishing processes. Lastly, there is a review of various specialised equipment used by the iron and steel industry.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. III—(*Continued from page 559, April 12*)

MR. LLOYD WOOLLARD, M.A., was in the chair when the meeting was continued on Wednesday afternoon, March 27, with the reading of :

MODEL EXPERIMENTS ON A SERIES OF 0·70 BLOCK COEFFICIENT FORMS

PART I

THE EFFECT ON RESISTANCE AND PROPULSION OF VARIATIONS IN *LCB* POSITION

By R. E. BLACKWELL, B.Sc., and G. J. GOODRICH, B.Sc.

SYNOPSIS

This paper describes, and presents the results of, experiments carried out to examine the effect of variation in the longitudinal position of the centre of buoyancy on the resistance and propulsion characteristics of a series of 0·70 block coefficient forms. The experiments were carried out for the British Shipbuilding Research Association by the Ship Division, National Physical Laboratory.

The resistance experiments were carried out on five models covering a range of *LCB* from 1 per cent L aft to 2 per cent L forward of amidships *BP*. Complementary self-propulsion tests were carried out over a range of *LCB* from amidships to 2 per cent L forward of amidships. Three propellers were used on each model tested to examine the effect of propeller diameter.

The experiments show that up to a speed-length ratio of 0·70 the *LCB* position is not critical as regards resistance, but above this speed *LCB* amidships appears to be the optimum for this series. The effect of variation of *LCB* on the components of propulsive efficiency is small, the effect of variation of propeller diameter and speed being more marked.

PART II

EFFECT ON RESISTANCE OF VARIATIONS IN BREADTH-DRAUGHT RATIO AND LENGTH-DISPLACEMENT RATIO

By R. E. BLACKWELL, B.Sc., and D. J. DOUST, M.Sc.

SYNOPSIS

Part II of the investigations made on a series of forms of 0·70 block coefficient, by Ship Division, N.P.L., in accordance with instructions received from the British Shipbuilding Research Association, was to assess the effects of variation in breadth-draught ratio and in length-displacement ratio on resistance. Experiments were carried out on nine models of merchant ship form and of 0·70 block coefficient, the tests falling into two groups : one giving a range of breadth-draught ratio with constant displacement and length ; one giving a range of length-displacement ratio with constant breadth-draught ratio. One hull form was common to both groups.

The results show that the effect of increasing the breadth-draught ratio above 2·12, the value of this ratio for the parent form, is to increase the resistance coefficient © over the whole working range of speed and at all draughts. Decrease in length-displacement ratio gives an increase in resistance coefficient © at all draughts. The increment becomes greater as the length decreases from 400ft and as speed-length ratio increases, but is less marked as draught decreases. The results are also shown to be in good agreement with the work of other experimenters.

DISCUSSION

Mr. M. N. Parker : A point I want to raise concerns Part II. I have been connected with work on the B.S.R.A. methodical series, and my impression was that the main idea of carrying out these tests other than at the load draught, i.e. at the medium and ballast draughts, was primarily to guard against the possibility of selecting a form on the basis of a series of tests carried out for the load draught only and then finding that it gave a rather bad performance in the medium load and ballast load conditions.

I was therefore surprised when I read the paper and still more perhaps when Mr. Doust began to emphasise the point that this lighter draught data should actually be used for determining the resistance of a different kind of form. Admittedly, from the data, it appears to be an abnormal form, and my impression is that it will be abnormal at the medium draught, when the cruiser stern is out of the water, and at the ballast draught, when the propeller aperture is coming out of the water. I feel it is quite unnecessary, unless we are dealing with some very unusual type of form. We have, for example, a similar series of 0·65 block coefficient forms with which we have made the same B/*d* variations, and these suggest reasonable forms for the lower block coefficients.

This point needs stressing because I notice there is a tendency to use data for another form at another draught. Then one has peculiar things happening, such as the bilge radius being unnecessarily large.

Figs. *a* and *b* are really extracts from the hydrostatic curves for these forms, and as such they provide useful data. But I am alarmed when they are described as showing the range of block coefficient covered. It seems rather to suggest that this is a way of getting block coefficients for other forms. A similar thing occurs when we turn to the cross curves at the end of the paper. In Fig. 24 the length/displacement ratio is given in the bottom line under each set of curves and is the real one for that particular job. It is useful to have it, but it is not immediately apparent which belongs to the design of length/displacement ratio and which would be the load draught one. It would not be correct, for example, at a given length/displacement at a ballast draught of a few feet.

Turning to Fig. 17, it has been explained that the increase in resistance with increasing beam was accentuated at the lighter draught. That is true, and when you consider the form particulars for the lighter draught, it seems to be just what we should expect.

Professor E. V. Telfer : I suggest that the work can be best appreciated so far as centre of buoyancy influence is concerned by considering the fore and after bodies separately and realising that the fuller the fore body the more rapid the increase in © at the higher speed value, but the lower it is at the low speed end of the curve. In other words, you get a forward centre of buoyancy by having a full form forward, which will result in a wake penalty. On the other hand, it automatically produces, in this particular presentation, a fine form aft, and there you can get the advantage at the low-speed value.

In some work I am doing, a gradual accumulation of statistical matter, it is far better to think solely in terms of the fore body itself and to introduce as a correction not a percentage on buoyancy, but a correction solely for the relative fullness of the fore and after body.

In Fig. 25 of Part II the authors compare the Todd series 60 results with their own. I suggest it shows that the series 60 models are more turbulent at the lower speed than are the Teddington models. What I would have done would have been to fit studs to that particular model in order to see if I could repeat the Todd results more closely than they have. I see that the authors have taken some credit that they can beat the Washington results at the slow speed ; I suggest that is completely illusory and that the gain is due to eddying and could be explained by laminar flow. On the other hand, there is much more wavemaking with the Teddington model than with the Washington models. The increase in © from 0·65 to 0·85 is greater in the Teddington case than in the Washington case, so that you have to be careful in drawing conclusions.

It is quite easy to show that in the general case a beam/draught ratio of 2·7, where both beam and draught are unrestricted, is the most economical to use, and the presentation in this case may give an entirely wrong conclusion, quite apart from being difficult to appreciate. Finally, I suggest that in both these cases, in addition to the details of the total © value, the authors should give also in both papers a presentation of the skin friction part of the total ©. That will enable us to swing from one presentation to another, and that would effect a great saving of time for anyone who has the inclination further to analyse the information given in the papers.

Mr. Woollard was joined by Mr. Longmuir, the chairman of council of the Institute of Marine Engineers, for the second paper of Wednesday afternoon, the meeting being held jointly with the Institute of Marine Engineers. The paper was :

FURTHER SEA TRIALS ON THE "LUBUMBASHI"

By PROFESSOR G. AERTSSEN

SYNOPSIS

The "Lubumbashi" trials, of which the results have been published hitherto, were carried out on a newly built ship. It was decided by the Centre Belge de Recherches Navales to take advantage of the instrumentation of this ship, especially the torsionmeter, the thrustmeter and the pitometer log, to make further investigations on the behaviour of this vessel as she became older.

Renewed measurements on the engine running on heavy fuel made it clear that heavy fuel is appropriate to a diesel motor from the point of view of the economy of the ship.

Records taken in varying weather conditions during two Atlantic winter voyages, with two different draughts, threw new light on the effect of weather on ships' speed.

Great attention was paid during the first three years of the life of this vessel to the increase of frictional resistance. Information on the subject is given by speed, thrust and power data, as well as by pitot traverses taken over the bottom in the centre line, fore, amidships and aft. An attempt is made to correlate these data with the results of roughness measurements.

DISCUSSION

Mr. G. Dufour : Professor Aertssen is more than an efficient scientist. He is also a seaman and, as such, he is accepted by the ship personnel, and long after he has left the ship the officers and engineers continue, as far as is in their power, to keep as good records as they can.

That is an important point to a shipowner : the wealth of data and curves provided by Professor Aertssen give us a more accurate knowledge of the behaviour of our ships at sea. But Professor Aertssen can never be at sea all the time and in all the ships. Therefore what he measures is unavoidably a particular case, not an average, and at best he is measuring accurately a few spots on a general pattern. However, if the shipowner can also rely on well-kept voyage records, he can in the long run get the general pattern.

The measurements made by Professor Aertssen over a peroid of twenty-six months give an increase of total resistance by surface deterioration of 14 per cent. The analysis of voyage results of the same ship over the same period gives us an increase of 12 per cent ; thus, it is encouraging that from ordinary voyage result analysis we can arrive at a figure which is not so far off that given by scientific measurement. The percentage is

large and in that respect the "Lubumbashi" was a disappointment to us. We took the trouble to sandblast the hull in drydock and painted her with what we thought was the best available paint and yet very quickly there was a surface deterioration just as bad as on many older ships where no such care had been taken.

The second ship, the "Lubilash," was sandblasted when new and painted in very good weather with a different paint from that used on "Lubumbashi." After eighteen months of service, the surface deterioration tends to show only 4 per cent increase in total resistance. The next vessel, the "Lufira," was not sandblasted when new, but was painted in bad weather with the same paint as the "Lubilash." The result after eighteen months of service seems to be about a 5 per cent increase.

As time goes on, we might have sufficient data to be able to see whether the sandblasting was really worth the expense, and whether the second quality of paint was better than the first. I emphasise once more how important a good application of good paint is to a shipowner; indeed, all the devices the engineer and the naval architect introduce to increase the propulsive efficiency of the vessel or to lower the fuel consumption can be spoiled by a bad coat of paint.

Mr. H. J. S. Canham: It is apparent from the work Professor Aertssen has done that the use of the pneumatic gauge has considerable advantages for new ships. A very large number of readings can be taken in a short time and the accuracy appears to be quite acceptable with small roughness; there is good correlation with sand roughness.

The B.S.R.A. has a lot of data on roughness and has found the same skew distribution on new ships as shown in Fig. 10. That is frequency distribution. In trying to assess the accuracy, the logarithmic transformation of the roughness data was used to take the skew out of the diagram and get a more Gaussian distribution.

The B.S.R.A. has little information on ships in service, but what we have lines up with the histrogram in Fig. 11. We also find gaps in certain of the ranges of size, and attribute this to the fact that we were taking small samples.

I challenge the remark by the author, in reference to a ship where roughness was measured, eight months after painting, only between the high and low waterlines, that probably the bottom of the ship was rougher than the sides. We have limited experience of that, but we get the same roughness for the bottom and sides of a ship after twelve months or so of service. An interesting point is that the bottom was scaled and the sides were not. In two cases where readings were taken after the ships had been out of dock for twelve months, the roughness increased by 130 and 160 per cent respectively; there was complete absence of fouling. After cleaning and painting those increases of roughness were reduced to about half. The "Lubumbashi" showed an increase of 70 per cent after the first six to seven months, but after cleaning and repainting the roughness was only about 6 per cent more than when the ship was new. It seems, therefore, that the cleaning and repainting must have been well done. At the B.S.R.A. we have data for a ship seventeen years old. After being cleaned and repainted, the roughness was from four to five times the value expected for a new and well-painted ship. That suggests that the rate of increase of roughness falls off appreciably as the age of the vessel increased, and this is supported by the "Lubumbashi" results.

It is quite plain from the diagrams in Figs. 20 to 23 that this ship is operated at constant power, and it seems to me that the important thing is not so much the increase in power, but the decrease of speed under constant power conditions.

Mr. D. J. Doust: This aspect of hydrodynamics is of increasing importance to shipbuilding generally, and the supply of this sort of data under controlled conditions will yield solutions to problems which remain unsolved.

Tables I and II (in the Appendix) give weather data, and the angles given in the tables seem to be remarkably small. It is stated that the pitch angles were measured by a recorder of the pendulum type, and I ask what was the reason for that and whether gyroscopes would not have been perhaps better for a continuous record.

In Section 5 it is stated that "there seems to be no appreciable difference between fully loaded and medium loaded condition in so far as the effect of weather on speed and propulsive efficiency is concerned." To what does Professor Aertssen ascribe that? Normally for the same sort of conditions one would expect a greater windage on the above water form.

My last point, which is very much in our minds with the smaller class of vessel in service, is a falling off in the characteristics of the propulsion unit, and I wonder whether, as the result of these full-scale experiments, it is considered that in the assessment of the actual trial trip conditions some consideration should be given to the inevitable loss in performance which arises in service and how that affects the propeller design.

Dr. J. F. Allan: I appreciate the frank statement concerning the limits of accuracy of the various measurements, and it is important to bear in mind these limits of accuracy when looking at the paper generally, for the worse the weather, the greater is the spread we must expect in the data.

The fact that in a moderate following sea you get some advantage is one which most of us have known from experience and log analyses. I note the increase of power figures of 29 and 37 per cent for the two Atlantic voyages. Those are increases due to weather conditions only; if to that we add at least 5 per cent for general deterioration and fouling we arrive at a figure of between 35 and 40 per cent, which is not much different from that allowed for such vessels in general service conditions. I feel that the evidence produced in this paper supports the view that an allowance of the order of 35 per cent is necessary for services in the North Atlantic.

I can quite understand Mr. Dufour's disappointment concerning the bad deterioration of the plating surfaces of the "Lubumbashi," despite the trouble that was taken to sandblast the hull to obtain a good surface. This matter of protection is very important. Chemists assure me that there is no paint known which will prevent corrosion taking place under it in time, that salt water will penetrate anything, and, therefore, there is bound to be deterioration of the surfaces, no matter how carefully we clean the steel to give a good surface for the paint.

Professor L. C. Burrill: I think the owners of the ship are fortunate in being able to find a man with his knowledge of the subject and his care in taking these readings who will go to sea for long periods at short notice. I wonder whether we cannot do the same kind of thing; a young research student might well render very useful service by going to sea and taking these records carefully, and then later presenting the result in the form of an analysis such as this.

In connection with the log analysis work the effects of weather from different directions are brought out very clearly in Fig. 21, and in some ways the figures are frightening. There is increase of power of the order of 120 per cent, and I can only think that these are the results of really bad weather. The diagram in Fig. 20 is typical of those I have obtained from the analysis of ship logs kept by the ships' personnel, and a diagram of this kind reveals what is happening on the ships. It is quite evident that the engineers are trying to maintain the full power of 5000 d.h.p. all the time, and that object is defeated to only a small extent, i.e. the falling off of power is small as between good conditions at sea and very bad conditions. Therefore, it seems that the reason for the differences in performance is the loading of the propeller which occurs when there is bad weather. I would like to see whether we can draw some further information from this diagram. For instance, I would suggest that it would be useful to analyse, using open water curves of the propeller, the wake values in the different kinds of weather.

Professor Aertssen has been able to do something we cannot normally do; he has measured the thrust h.p., and I would like to see what is the relationship between the e.h.p. which the tank would have determined and the e.h.p. he gets from his thrust measurements. If the results do not give consistent wakes, we should learn something about the propeller, for I cannot imagine that the propeller efficiency should fall as much as 18 per cent.

Professor E. V. Telfer: It will be appreciated that in the diagrams Professor Aertssen is showing that increase of total resistance from either surface deterioration or fouling, or in combination, is not a linear function with time, but something which increases very rapidly at the start and gradually slows down as time goes on. Therefore, any statistical analysis based on the assumption that the function is linear must itself be erroneous. That does not interfere with statistical analysis. You have merely to find the time function which is in harmony with observed facts, and you can go back to your analysis and draw possibly a conclusion from other factors than the fouling.

Mr. H. Baxter: We see from the statistics given in Table I, where the description of the sea is related to the height and the length of the waves, that, even when the weather is classified as very rough, the ratio is of the order of 1 in 30. We all know that the standard L.20 wave is not usually met; but here, even in the very rough sea condition, we find the discrepancy from the L.20 wave has grown until it now becomes L.30, and this would fit in with the formula which gives the relationship between height and length of wave as deduced from the "Ocean Vulcan" trials.

I wonder if there is a possibility of having fitted throughout this vessel, or any other, a statistical strain gauge. We can tell from the results obtained by the gauge how many times there has been a stress of, say, 6, 5 and 4 tons per square inch, and how many times a stress more than a minimum of 2 tons per square inch has been reached. Those figures would be of interest in relating the bending moment, and, hence, the stress, with the wave conditions for a particular ship.

Commander Peter Du Cane: The Beaufort scale for wind velocity is by its definition somewhat approximate in relation to the actual velocity of the wind at any given time. It is the sea state which is of importance and it may be conceded that the method of

measuring wave height as observed on the ship's side is not altogether satisfactory. To consider the limit case, an infinitely small vessel in an infinitely large sea as regards height and distance apart of wave crests would indicate no height difference on the ship's side. Some method such as that developed by the Institute of Oceanographical Research might be considered. Here vertical accelerations are measured and integrated twice to give velocity and displacement.

Professor A. M. Robb was in the chair when the spring meeting was continued on Thursday morning, March 28, with the reading of papers Nos. 6, 7 and 8, which were jointly discussed. The papers were :—

INTERACTION BETWEEN A SHIP'S HULL AND A LONG SUPERSTRUCTURE

By J. C. Chapman, Ph.D.

Synopsis

Owing to transverse distortion of the hull, the deflection of a ship's superstructure is not, in general, the same as that of the hull sides : the stress in the superstructure, therefore, differs from that calculated by the simple theory of bending on the assumption that the hull and the superstructure act integrally.

This paper gives a method for calculating deflections and stresses in the hull and superstructure, taking account of the differential deflection. Changes in cross-section of the hull or superstructure and in the transverse stiffness of the supporting deck present no obstacle. Only those concepts familiar in the simple theory of bending are used, and shear lag effects are ignored, so that the method is applicable only to long superstructures.

The work described was part of an investigation undertaken for the British Shipbuilding Research Association.

Differential equations governing the deflection of the hull and superstructure are formulated and the relaxation technique is used for their solution. The method is one of successive approximations, and is sufficiently flexible for an inspired anticipation of the solution to be put to good advantage. In certain simple cases the governing equations can be readily integrated, and such exact solutions enable the accuracy of a relaxation solution to be estimated.

The solution of the problem entails an assessment of the transverse stiffness (foundation modulus) of the supporting deck, and some suggestions are put forward for estimating this property. Fortunately, the behaviour of the superstructure can be described with fair accuracy even if this estimate is only approximate, and where several bulkheads are present it may be reasonable to assume that the foundation modulus is zero.

STRESSES IN DECKHOUSES AND SUPERSTRUCTURES

By A. J. Johnson, Ph.D.

Synopsis

The investigation described herein was undertaken with the object of devising methods of estimating the contribution of deckhouses and superstructures to the flexural rigidity of ships. The work represents one aspect of a comprehensive programme of research being carried out by the British Shipbuilding Research Association.

Earlier published work on the subject is briefly reviewed. While some of these publications provide valuable information on the mechanics of the problem, it is concluded that most of the solutions proposed have very limited practical application.

The problem is discussed in a general way, the various factors influencing the deckhouse and superstructure characteristics being enunciated. It is shown that simple bending theory is inadequate to deal with the problem and recourse must be made to plane-stress theory in order to provide a foundation for the treatment of the subject.

General solutions are obtained in an idealised form of the problem, and by the application of approximate corrections the solutions can be adapted to predict the structural behaviour of any particular kind of deckhouse structure within the limits of the analysis. Owing to the complex nature of the problem, it would appear improbable that an exact solution can be obtained. The proposed solutions are of such a nature that the operations could be carried out quite simply.

Several worked examples are given in order to illustrate the sequence of the calculations and to show the general effect of introducing expansion joints into a long deckhouse.

The adaptation of the proposed solutions to the case of the light-alloy or composite steel-light-alloy deckhouse is discussed briefly.

EFFECT OF SUPERSTRUCTURES ON THE LONGITUDINAL STRENGTH OF SHIPS

By J. B. Caldwell, B.Eng., Ph.D.

Synopsis

A theoretical analysis is presented of the behaviour, under any distribution of longitudinal bending moments, of ships with superstructures. The stress distribution in the superstructure is complicated by various non-linear effects, not usually considered in conventional strength calculations, such as shear lag in the superstructure, deformation or "slip" in the connection between superstructure and upper deck, and differential curvature between hull and superstructure due to flexibility of the upper deck. These factors influence the contribution of the superstructure to the longitudinal strength of the ship, and have therefore to be considered in calculating the "efficiency" of the superstructure.

Following the general theoretical analysis, a practical method for estimating superstructure efficiency is given. Numerical results are then obtained, which show how superstructure efficiency varies with the ratio of its length to transverse dimensions, with the flexibility of the upper deck, and with the distribution of bending moments applied to the ship. The theory and results concern single-deck superstructures ; but the method may evidently be extended to multi-deck superstructures.

Discussion

Mr. John Brown : No independent shipbuilder could devote the time that has been given to the work described in the papers, and I doubt whether any independent shipbuilder could deal with the elements of the mathematics and the abstruse problems uncovered in the papers. To that extent we are much indebted to those who have assisted us in this matter through the association.

In deriving stresses in superstructures, the methods used are fundamentally similar in attempting to determine the forces necessary to give compatibility of flexure of the deckhouse base and the main deck of the hull. All methods take account of the comparatively recent conception of the flexural rigidity of the main deck of the hull by means of a term referred to as "foundation modulus" or "deflection coefficient" or "deck flexibility."

Dr. Johnson and Dr. Caldwell concentrate on the stress at the mid-length of the superstructure, and Dr. Johnson assumes mathematical similarity of the deflected shapes of the superstructure base and the hull girder main deck at side ; thus, his deflection coefficient "C" expresses the relative overall difference between deflection at the plane of the deckhouse sides and the deflection at ship's side.

Dr. Chapman also derives the relative differences in deflection between the deckhouse side and the ship's side, but his relaxation procedure gives these differences along the whole length of the deckhouse—he is then able to incorporate the effect of rigid bulkhead supports as producing zero relative deflection at their appropriate positions. Dr. Johnson's comprehensive deflection coefficient "C" permits the derivation only of the relative difference at midships. Nevertheless, it may be seen that the general effect is similar from comparison of Fig. 5 of Dr. Chapman's paper and Fig. 7 of Dr. Johnson's paper.

The similarity of experimental and calculated results shown in Fig. 4 of Dr. Chapman's paper demonstrates the probable usefulness of his method, assuming that satisfactory values may be obtained in practice for the foundation modulus. It may be observed that Fig. 4 applies to a box girder with a two-deck superstructure, and the contribution of the superstructure has been incorporated by a straightforward inclusion of its area and second moment of area without allowances for effective width, sheer lag or similar effects.

It is suggested that the application of Dr. Chapman's relaxation method to a number of cases such as those shown in Dr. Johnson's Fig. 22, might provide the necessary "k" values which could be used for future investigations and with this method would prove sufficiently accurate for the determination of stresses and hence scantlings of the superstructures likely to be met with in practice.

Mr. I. M. Yuille : Ships with long superstructures generally have bulkheads fairly closely spaced, and I have felt that these would tend to make a superstructure bend with the main hull much more effectively than the relatively flexible deck beams. Dr. Chapman presents us with a practical method of calculation, in which one can include the effect of bulkheads in the main hull. We also have their effect demonstrated for the first time by his Fig. 5, which makes it clear that if the superstructure covers five or more bulkheads fitted in the main hull, the superstructure will bend as part of the main hull and the ordinary theory of bending can be applied to the combination.

Dr. Chapman warns that the forces between the bulkheads and the superstructures are high, and states that the connections can be regarded as rigid only if they are so designed. Any movement of the superstructure relative to the hull at these points is liable to cause local troubles, but it should not be difficult for the shipbuilders to design rigid connections. I think nobody will suggest that we should have expansion joints which flex up and down. Where there are fewer than five bulkheads, I think Dr. Chapman's method of analysis should prove most useful to shipbuilders generally.

It is possible for numerical errors in the relaxation process to pass unnoticed, so that although the residuals are apparently reduced to zero, the values of y may be incorrect. To guard against this it is important to check the calculation, which can be done by using the calculated values of y as the "initial guess" ; the residuals found, as shown in the example in Section 5 of the paper, should be zero if correct values of y have been calculated.

In short superstructures it appears that shear lag is much more important than in the longer ones. The analyses of Dr. Caldwell and Dr. Johnson apply where there are no bulkheads, and that is fortunate, because where the superstructures are short it is likely that there are no bulkheads underneath them. It would be useful to know the length of superstructure below which shear lag becomes so important that Dr. Chapman's analysis is no longer sufficiently accurate for design purposes.

Mr. J. M. Murray : Dr. Chapman has shown that where there are five or six bulkheads under a long superstructure the foundation modulus can be taken as zero or, in fact, as any number. I think that Dr. Chapman's hull and superstructure deflections compare with the deflection coefficients in Dr. Johnson's paper ; there is substantial confirmation between the results of the small-scale experiments and the results of the investigations in the large-size ship.

The papers by Dr. Johnson and Dr. Caldwell will be useful to designers of deckhouses and superstructures. We in Lloyd's Register are already acquainted with Dr. Johnson's methods and have done some design curves using these methods, and shall certainly compare the results with those which will be obtained by Dr. Caldwell's methods.

One assumption that both Dr. Caldwell and Dr. Johnson make is that the deckhouse side is a homogeneous plate. In practice, it is anything but that ; very few deckhouse

sides are in the same plane fore and aft; most are pierced by large windows; there are recesses for entrances. I think the result of this is that the expansion joint may in practice have to be retained, and it is of interest that there are more large passenger liners with expansion joints than without. I do not think we get very much trouble with expansion joints. I suggest that this matter of expansion joints requires a lot more attention, and that one method of determining the real efficiency of a deckhouse would be to make model experiments on the lines of those by Dr. Chapman, with the deckhouse side pierced instead of being solid.

It is only very recently that the work of Mr. Foster King and Dr. Montgomerie has been superseded by these new methods, which are bound to have a pronounced effect on the design of long deckhouses in ships.

Dr. W. Muckle: The problem of the longer deckhouses is the problem of discontinuity and I suggest that mathematically it is insoluble.

In the various methods it is naturally assumed that the marginal stresses at the end of the superstructure are zero, but where the superstructure is attached to the hull you must go to a finite stress in the hull, and therefore you have a constant change of stress from one to the other. I do not think any of the methods put forward get over that difficulty.

I think that the stress function in dealing with this problem leads to an excellent solution. But difficulty arises where you get this change over of stress. Would the authors care to say what sort of distribution they would get in a long deckhouse assuming the deck flexibility factor is zero or infinite.

In his paper, Dr. Johnson has neglected the effect of shear lag and it is suggested that in the longer houses this is a negligible factor. I feel that for houses which are, say, 40 per cent of the length of the ship, the shear lag effect is not negligible. In some simple experiments I carried out on aluminium superstructures there was a tendency for there to be shear lag throughout, and it was quite marked, I think, at about 40 per cent of the length of the ship.

I think that to get the best out of the superstructure you should have it as effective as possible. It may be suggested that the addition of webs or partial bulkheads, as indicated in the papers, would assist, and perhaps pillaring under the deckhouse sides would be increasingly effective in improving efficiency. With aluminium superstructures I think it is even more important that they should be made fully effective, because of the peculiarity of the composite structure problem.

Mr. B. N. Baxter: These three papers enable this complicated problem to be solved by applied mathematics rather than by empiricism. Dr. Caldwell shows how to calculate the efficiency of a superstructure in a quick and relatively simple manner. Using this efficiency, and the area of the section, the contribution of the superstructure to the total strength of the complete ship section may be obtained. Hence, the amount by which the main hull scantlings could be reduced because of the presence of the superstructure may be determined. In vibration or deflection problems, the amount and distribution of the moment of inertia of the superstructures, particularly at the ends, is of great importance when calculating the frequency, using one of the direct methods of calculation.

Dr. A. J. Johnson: One assumption common to all three papers is that simple beam theory holds good within the main hull girder. A study of published data will reveal, however, that there are often considerable discrepancies between measured and predicted stresses and that these frequently occur at positions which are structurally important.

The papers deal in the main with the analysis of idealised forms of structures and there is possibly too little regard to the implication of the results for design purposes. The designer is sometimes confronted with the problem of whether or not to incorporate expansion joints. If, for reasons of stability, it is desirable to keep to minimum scantlings in a deckhouse, there may appear to be little alternative to the introduction of expansion joints, which are often a source of trouble.

It would seem logical to suggest practical means of minimising stresses in deckhouses by suitable design techniques.

Possible means are:

(1) To arrange the foundation modulus as defined in Dr. Chapman's paper to ensure that the degree of curvature in the main hull can never be fully developed in the deckhouse; (2) to interrupt the longitudinal continuity of the deckhouse sides so that they would be incapable of effectively transmitting the shearing stresses to the upper parts of the house; (3) to improve the fashioning of the house ends into the main hull in order to reduce the magnitudes of the local forces in these regions; (4) If expansion joints are considered desirable, then to produce a design which will avoid the high local stresses which commonly occur at the roots.

Dr. Chapman has demonstrated by theory and experiment that the degree of curvature may vary a great deal with distance from amidships towards the house ends. Thus we have a condition which, based on Dr. Caldwell's definitions, can produce a superstructure efficiency well in excess of unity at certain positions which are dependent upon the bulkhead positions and may be some distance from amidships.

From the point of view of the overall contributions of the deckhouse to the flexural rigidity of the hull, it might be useful if the stress distributions given by Dr. Chapman could be integrated longitudinally to give a mean value of the effectiveness or efficiency. Such calculations may well produce figures which would not differ greatly from those given by Dr. Caldwell's method.

Professor E. V. Telfer: I was rather struck by the observation, in the introduction to Dr. Chapman's paper, that "It has always been realised that this contribution" (of a superstructure to the overall longitudinal strength of a ship) "cannot generally be estimated from the simple bending theory ..." Neither in Dr. Montgomerie's paper nor in Mr. Foster King's was there any suspicion about the simple bending theory as applied to this problem.

Many years ago I busied myself with the theory of a beam within a beam, but was unable to get very far with the idea. However, we are now getting a really clear idea of the mechanism involved in the superstructure. I would like to suggest that my original terminology of the theory of a beam within a beam should be extended to the study of parasite structures in a ship, and I think that would throw a flood of light on the whole principle of ship construction.

Dr. S. Livingston Smith: We started, as you know, with simple box girders and built them up, wedding theory to experiment, until we reached the position we have reached to-day. Many of you have said that we must go further with the model experiments, but, at the same time, do all the experiments we have the opportunity to do on actual ships. You are now looking at papers which had their origin five years ago, and it does take time to seek the right opportunities to carry out the experiments and make sure they are a success, with the help of the shipowners. After all, we in the B.S.R.A. belong to the shipbuilders, and it is only by the kindness of the shipowners that we can make these experiments.

(*To be continued*)

Wear and Tear

By JAMES JOHNSON, M.I.R.T.E.*

On Thursday last the Institute of Road Transport Engineers had an account of some of the troubles experienced and remedies evolved by an engineer maintaining a fleet of heavy vehicles. Particular attention was drawn to the shortcomings of tyres and transmissions, and to the difficulty of supervising a large organisation.

Tyres

To begin on the ground floor, as it were, the subject of tyres in use can give a variety of both annoying and, at the same time, interesting problems which, if the vehicles are to be an economical proposition, must be solved, and speedily.

Problem number one caused a grey hair or two before a solution was found. Three perfectly sound, 12-ton, oil-engined articulated vehicles, comprising two different makes, were docked at around the 85,000 mark, and then turned loose to earn their keep. Perfectly sound tyres were on all wheels and were well-matched. One can imagine the surprise at 6000 miles after dock when the offside trailer inner cover was found to be heavily pocketed and in the cavities was showing the thread. Promptly, the rear axle alignment was checked and found to be correct. Both rear springs were measured between centre and end bush; both were split, and the dimple or centre bolt, as the case may be, was checked again and everything was in order. Braking was checked, as also were servo units, and again all were correct. Temporarily blaming that particular cover, wheels were changed round and a further 4000 miles were run, and again the signs were the same, namely, offside inner trailer tyre showed irregular wear, whilst the outside cover was untouched.

In the meantime vehicle number two began to display similar tendencies and number three, a rather higher model also, gave trouble with the nearside inner tyre. This was too much and, therefore, number one was promptly brought in and divided, and a real inquest was held. Repairs had been made to the body and also to the turntable sub-frame on both chassis and trailer. Tape and rule found all correct. The trailer rear axle was then checked and found correct.

Something had to be done. Casually poking at the friction disc in the turntable ring, the writer noted that it could be spun by one finger. The writer had it out at once and found a dance floor finish on both upper and lower steel surfaces, plus a glassy glaze on the disc. The disc was promptly changed for a new metallic one and the facing plates lightly stoned. Number one was then assembled and turned loose. Number two, being of the same breed, was found to be likewise. Number three was not fitted with a friction disc but had skids, it being possible to lean the body an exceptional amount before

* British Road Services.

the skids touched. They were built up and given ⅛in clearance; this checked the lean and, as it turned out, the tyre fault also. Numbers one and two had suffered from excessive head movement, and the trailers had for some time been in the habit of dropping down the camber causing the wear mentioned.

This particular trouble is common to rear tyres on four-wheeled trailers also, and the apparent cure is a fairly heavy turntable movement. This can be arrived at by keeping good friction discs and seatings and an additional cure is to limit turntable tilt to the minimum, by keeping pins, bushes and skids, if fitted, to very close fits. The lean of a body, due to turntable wear, is one of the causes of bad tracking or following, and very soon begins to cause considerable increase in tyre costs. The human element comes into this, unfortunately, and often undoes the good work of the maintenance people: the drivers like a free turntable to allow them to manhandle and also reverse the trailer.

For the four-wheel trailers, the answer is to fit a front towing attachment to enable them to be pushed and pulled, and the drivers will put up with a reasonable amount of turntable drag. In referring to a stiff turntable this means that a damping or retarding action is required in movement by hand of the drawbar. It does not mean that the unit must be bone dry and difficult to move. A very slight retarding effect is enough to stop crabwise running.

In the case of the driver of the articulated vehicle, his complaint is that he needs a free head movement to allow quick and easy action on reversing. It is of little use telling him that you want to keep the friction plates dry and save tyres, for he will only say: "That's all very well, but how am I going to back in to a place where it needs full lock both ways with only inches to spare?" In this case, one is due for a regular grumble from this man as it is clear that only by keeping the turntable in 100 per cent condition can one hope to obtain maximum life from the trailer rears.

Another headache on this type of vehicle, either articulated or four-wheel trailer, has a habit of sneaking up on you and adding to your tyre costs: it can happen in this way. You may have a four-wheeler running solo and for the sake of a little more driving comfort and also to cut down cab shake, especially on light runs, you very considerately fit a pair of 9.00×20 or even 10.00×20 front tyres. This can happen on the articulated vehicle also, as this short wheel base machine is often a bumpy ride if not fully loaded. Your articulated vehicle is considerably improved and you are quite content and the weeks roll on. In the meantime along comes a new trailer, ordered some time in the past, and you promptly fit a drawbar and prepare to drag a bit more payload. Again you test the outfit and off to work it goes.

Being busy as always, it is some little time before you and the articulated vehicle come face to face and you are immediately shaken by the appearance of the front covers, which now resemble craters on the moon. Hub check, toe in, pressures, loads and amounts carried recently, all follow in line, and amongst all these you find odd bits here and there to do, so back on the road goes the outfit, plus two new 10.00's or similar covers, while off to the factory go the worn ones. Meanwhile, someone mentions casually: "Have you seen the front tyres on the new wagon and trailer?" You make it your business to do so, and once more begins a considerable flap. There are more pockets on those front tyres than in a poacher's jacket. Once again the same sequence of events, pressure check, even painting this on the wings, amounts carried, hubs, look for oval or warped brake drums, toe in, &c., and again, finally, one says "O.K., take it away."

The articulated vehicle having in the meantime put 18,000 more miles on the clock, you have a check on this vehicle and see already the irregular wear taking place. As you know that any flat or hollow on a cover is speedily played upon and worsened, as in the days of the old solids, you therefore seriously begin to watch points and finally do some considerable mileage at the helm, loaded and otherwise. You have a good gallop and while sailing along you are almost unaware that you are driving an articulated vehicle, except for the gentle prod from the rim of your driving seat. You notice also that the trailer headboard moves up and down in your mirror, and it is some time before the light dawns. Promptly, you hand over the wheel to the driver and tell him to carry on and, glueing your eye on the front tyre, you at once notice the flexing of that tyre. The movement seems exaggerated and out of proportion, as you know the pressure is correct. However, there it is, all the signs of under inflation, and yet the pressure is correct. There is now no doubt. That rise and fall, intermittent or otherwise, is pocketing the front covers, and it is then up to you to make a decision, either to change back to 36×8 and cure the tyre trouble, at the same time losing your smoother running, or, as the writer did, for instance, return to 9.75 or 10.0 and, ignoring the tyre people, push the pressure up 8 lb to 12 lb and split the difference. The two tyres the writer remembers well on the articulated vehicle had a fair life for his class of work. The O/S cover reaching 39,000 miles and N/S cover was removed at 10,000 less, due to damage caused by curbing. This tread, incidentally, would have stood a further 10,000 miles otherwise.

In the case of the lorry and trailer, pressure increase made no difference, there was still pocketing. A spring-loaded drawbar did not improve matters. Moulded front liners were fitted to reduce braking power on the front wheels and still there was no difference. The cure was to go back to 36×8 high pressure. All of this, one may say, cannot possibly be due solely to the difference between a 10·00×20 and a 36×8 on the front wheels of a lorry and trailer. Nevertheless, the pull-and-push action of a loaded trailer on a wavy road has a greater wearing effect on a balloon or low-pressure type cover than the slimmer high-pressure one, coupled with which is the fact that the trailer must positively have no fore-and-aft slack on the drawbar or pin. If a spring-loaded coupling is used it must be tensioned sufficiently to stop any tendency on the part of the trailer to hang back even momentarily, otherwise the front springs and tyres are overworked, which is the root of the trouble. Many arguments have bene raised, due to this diagnosis, but, without doubt, the steady nagging of the trailer in a fore-and-aft motion will play havoc with front tyres on the trailer or vehicle, and the answer is two-fold, namely, to keep to high-pressure tyres and to allow the minimum free movement at the trailer connections.

Another difficulty is caused by rear bogies on double-drive vehicles, apart from those fitted with the third differential unit. The majority of operators on long-distance heavy vehicles prefer, for a number of good reasons, to run a popular 40×8 cover. Being double-drive with two differentials only, the operator has to pay for quite a lot of rubber being pulled off during a slow turn in any full lock on this type of machine. Little is said of this, as good mileages are still obtained if good tyre control is maintained.

The real headache is the matching of tyres for the rear bogey. In the first place, although there are supposed to be tyre manufacturers' standards, it is possible to find up to 1½in difference in O/D between different makes of 40×8 covers, without any reference to "L" pattern covers. Among the whole of the makes within this 40×8 range, only rarely do more than two makes match within ¼in. To make matters a little worse another difference often occurs around the first 500 miles. A measurement taken then can sometimes show a ¼in growth on the O/D to confound you a little further, on certain makes. So having an O/D difference up to 1½in you will certainly have considerable difference in revolutions per mile also.

Checks on vehicles which have inadvertently had tyre mismanagement have given us up to 2½ miles per gallon increase after carefully matching all rear tyres.

So much for manufacturers' agreements to have standard measurements. Having been told to fit dual marked tyres as they are less liable to vary than the normal high pressure, the writer's answer is that many very sound, but slightly elderly, vehicles will not take the "L" marked cover due to insufficient clearance at the point of passage near the road springs, which if catered for by a wide outside disc would make the vehicle over width, so these old money-spinners must be kept on the straight tyres and one must do one's best with the wonderful range of tyre O/D measurements. In bad cases of ill-matching when the correct size could not be obtained, it has been necessary on occasion to order the removal of the drive shafts on the rear axle to allow enough freedom for the vehicle to return home with its load and save the certain differential trouble which would result if this step had not been taken. On numerous occasions well-meant advice has been passed to the writer, such as running permanently on single drive and one's trouble thereby being solved. To this, the 1956 answer is already becoming clear. On single drive with the new gross load an eight-wheeled vehicle and trailer totals around 33 tons; this weight has to be started and moved by four tyres if on single drive. Already records show very low mileages for these four tyres, as their individual maximum load, even at fourteen-ply rating, is only around 46 cwt, and the more constant application of 125 b.h.p. and more is already making itself felt. On double drive, eight tyres share the work and mileages are improved. Moreover, on single-drive differential life is shortened in hauling the above gross tonnage. To add even further misery, the same differences in O/D between makes is still evident, and amongst latest covers fitted, 1½in difference can still be found in overall diameter. So in the new range of covers this matching problem is still with us. However, as the tyre makers will not or cannot help, the engineer is advised to keep by him a good pair of 60in engineer's callipers, for they will certainly earn their keep a thousand times over.

The Chassis Frame

After tyres and the many problems connected directly and indirectly with them, all more or less expensive, we will have a look at the next important part on the busy well-used vehicle—the chassis frame.

This, once again, is a part of the vehicle which is often taken for granted and receives little attention until it forces notice upon itself by cracking, collapsing, bursting or just simply rusting away and finally breaking in two. In earning a living for its owner, let its life story be looked at and one will see how and why it might have served a little longer if it had not, like the sun and moon, been taken for granted.

A quick look at the ups and downs in its life causes one to wonder how it does survive. The chassis frame on the busy trunk lorry meets with the following hardships. From the moment the wheels begin to turn, the frame, for all that it has road springs and trunnion balance beams, is steadily on the move, twisting and returning to line again and again over heavy bumps, crossings, adversely cambered roads, sites, &c., is subjected to constant braking, including heavy emergency stops, and pull and push at all brackets and hangers. In its life it will, no doubt, be in the ditch many times and in at least half a dozen accidents, both small and large. In ditching it will be seen that the frame is forced into a fearfully twisted position, and the marvel is that it ever comes back into line again. Involved in accidents it becomes kinked in places, and this causes subsequent misalignment and failure. In snowy and icy weather the long suffering frame has a poor time indeed, as on frost and snow-bound roads it suffers wheel spin. Its total weight plus load will no doubt be 20 to 24 tons and often when wheels are spinning uselessly a shovelful of grit causes one wheel to grip under a lot of horsepower, and the frame has to take a hefty punch at the coupling point to that wheel. This goes on winter after winter. All this is in addition to bad loading, overloading and, very important but rarely remembered, high speed and no load at all, when springs are no longer flexible. They simply deliver every shock they receive. The shattering effect of empty fast running has to be seen to be really appreciated.

With all these horrible things happening the

frame has a hard time indeed, and, until it fails, it has little help from its owner.

Transmission

The task of coupling horsepower to road wheels, so far as the last twenty-five years are concerned, has changed very little. We have moved from flexible couplings to needle rollers, and we have had the third differential introduced, but whether we use worm, hypoid, double helical or anything else, we are all more or less happy about the machine when it is new. If it stayed in the new state we would be out of work.

However, things begin to happen after a while, and the engineer is then expected to cope in the best possible manner. Beginning at the clutch pedal, which often can tell its own story by its beautifully polished appearance, even more highly polished than the accelerator pedal, we can see that some one is using this pedal as a foot-rest for most of his driving time, and sure enough before we know it the thrust race is rough and noisy. A fault in many drivers' cabs is that there is no comfortable place for the driver's left foot other than on the clutch pedal. Provision for this space would save many clutch thrust races.

Leaving the clutch, which if treated fairly will serve well, we come to the gearbox and the evil thing called coasting. Coasting down long hills and slopes at speed is the reason for the engineer having many a late session. A realisation of what is happening in the box will help us to see the trouble looming up. In the first place we can assume that the journey has been long enough to thin out the gear oil and possibly lower its level a little. However, assuming it is still at the correct level and the gear is in neutral, what happens in the box is as follows. The constant-mesh wheel is idling slowly as also is the countershaft, and the oil is barely following the fixed wheels round. Meanwhile, higher up in most boxes, the final drive shaft is really beginning to motor round. This is not bad but for one thing, namely, that no oil is arriving at the final shaft rear bearing, or at the partly enclosed spigot bearing inside the top gear. This is without mentioning the almost fully enclosed skew or worm drive speedometer gear. These parts are now travelling at maximum speed, and it is doubtful whether any oil is arriving at these points. If tick-over is slow or, as in some cases, the engine is stopped, these parts run dry and the box fails, leaving the engineer wondering why. Certain modern boxes are now on the side-by-side principle, that is, with both counter and final drive shafts at one level. This is an improvement, as the front and rear bearings can reach the oil level at all times, but we still have the majority of boxes on the high and low-level system. Therefore I firmly believe that the engineer should frown very heavily on coasting at all times.

Before leaving gearboxes I would remark on the value of the magnetic filter or magnetised drain plug. This replacement drain plug is a good investment indeed. It is a sure means of collecting and isolating all steel dust and fragments and ensuring their removal at each oil change. The amount of whiskers and debris attached to the magnet on removal is a clear enough indication of the damage that is being done to the gears and bearings where this abrasive material is allowed to circulate undisturbed.

Engines

When our frost precaution notices are posted up we begin thinking of a headache due to commence before Christmas and due to last until around April. Having the welfare of our engine in mind, we carefully prepare radiator blanking plates of sizes to suit each engine and its known operating conditions. These plates we fit to the vehicle, and number them for that machine only, knowing them to be suitable for maintaining the correct engine temperature. We also know beforehand that only one driver in ten will abide by our careful preparations for the engines' welfare in the bad weather to come. We know only too well that on night trunk about 10 miles outward, nine drivers will produce nine assorted horse blankets, rugs, mats, old coats, &c., and will drape them completely over the radiator, with the one thought in mind of keeping the cab warm and snug. Down below or behind all these clip mats the engine is quickly above normal working heat and often at boiling point for many miles. On the return of our vehicle we find that the driver's signing-off sheet reports bad pulling, smell, smoke and other troubles. Possibly 600 miles have been travelled out and back and the engine was in good shape when taken over by the driver. For the smoke and bad performance we remove the injectors and to confirm our suspicions we open up each injector or nozzle holder. Of the thirteen items that form our complete injector we find the nozzle valve blue, due to intense heat, causing sticking, dribble, &c. In addition to all this we see traces of engine oil which has escaped from many places where it should not, and we are quite satisfied that our engine has been overheated for many hours, and untold damage has been done to the pistons, rings, cylinder walls and probably bearings. All this the engineer is aware of and over the years no real cure has been found. When in due course the engineer is on the carpet for his engine failures, he takes the answer with him, but how many managers are prepared to sack 10 per cent of their drivers just to cure this engineer's headache? In cases of this nature it appears that the engineer can only retreat into his shell, as the only reply he could make would be "We only mend them."

An oil engine after running with the pneumatic governor ineffective

To keep the fleet engineer still more on his toes we have another little matter, i.e. "governor interference," and the resulting damage to engines. Once again the engineer is often in the dark until an engine fails and damage has been done. This again is only happening on the trunk services, where the driver has the opportunity to increase his engine revolutions per minute and considerably lessen his driving time. Over a number of years we have come to expect one in twelve of our night trunk vehicles to be suffering from constant governor interference, and when as many as three or four different men handle the one vehicle in a week it is always difficult to catch the culprit. The methods used over the years have changed little, and are crude, and have very damaging effects on the engines. Roping is one favourite method on the faithful Gardner engine; a rope is attached to the exposed governor bar, and the rack forced back against the effort of the governor to move it with the speed increase. Here speed is increased with added fuel, and as there is no compensation by pump timing advance, the engine suffers accordingly. On the same engine we have had the cold starting mechanism jammed, and the bar allowed free travel for hours on end. This is very damaging, and dilution, overheating and heavy smoke and carbon are the result. To box off the governor units has been tried and this led to cold starting difficulties. Our only method of checking that this interference is happening is by setting up and scribing suitable points and waiting for these marks to be by-passed by the showing of new worn or polished areas. On venturi type control, seals are constantly broken and stop screws temporarily removed, to be refitted towards the end of the journey and cleverly rewired or sealed (see illustration). To prove a certain point in this interference menace an engine of 9 litres with a governed maximum revolutions per minute of 1800 was carefully fitted with a non-return type revolution counter fitted inside the starting handle tube and spring loaded against the crankshaft end. This vehicle does not normally have a starting handle. This work was carried out very neatly and, thanks to a local instrument man, was never spotted. The writer had expected an added 200 r.p.m. The shock the writer received on the instrument being examined can be well imagined by the reading which showed that somewhere on its journey the engine had reached 2421 r.p.m., which for that 15-tonner, if in its highest ratio, was 61 m.p.h. During that year, our worst, seven of these engines broke or loosened off their big-end bolts and connecting-rods came out through the crankcase side.†

The method of manipulation used in this last series of incidents was very simple, and unfortunately had originated in a fitting shop. The pump being C.A.V. "BPEGB" type, it was all too easy to unscrew the inspection plug, and with a two-pronged tubular tool screw down the spring adjusting nuts solid. This was enough to give the reading indicated by the meter, and it was still possible to obtain a near normal tick over. This particular spasm of interference cost us £1300 before a halt was called. To prove all this it had been necessary to box up a time recorder and have it despatched on certain of these machines to their destination, and with the co-operation of a traffic manager at the other end, have it returned untouched. This opened our eyes to the time taken for the run, and a real purge on the vehicles brought to light the rest of the interesting facts. To the normal-sized haulage business this interference with the resultant damage would be a really fearful set-back, and very drastic action would be taken very early. In the larger undertakings where this occurs it is all too easy for such incidents to be submerged in the generally large list of troubles, and remote control plus a fixed course of disciplinary procedure does not allow a local action of sufficient magnitude to be applied to the culprit. The movement of this disciplinary procedure is so slow and of such a minor nature that very little is achieved in the way of stamping out this costly interference to engine units. The engineer has two jobs to do in the discovery of this affair. The first is to provide a complete set of facts and figures relating to his findings and pass them to the department controlling the drivers, and the second job is to make very sure that no inspection plug, &c., can be removed by the wrong person, without it being immediately noticeable. Everything possible is sealed, pinned, screwed and riveted, in such a manner that even the pump room staff get upset. However, we have at least located, and cured from our angle, a very serious engineer's headache, and it is now very clear that the really interested road transport engineer need never have a dull moment.

† The lecturer related an instance in which several members had observed an A.E.C. in this condition exceed 53 m.p.h.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ADVANCED AERONAUTICAL EDUCATION

SIR,—At the Royal Aeronautical Society's conference on the above subject at Cranfield on March 23/24, I read a paper describing the training required by graduates entering the service of the Royal Aircraft Establishment and I did not, in fact, allude to the many opportunities for advanced post-graduate education open to the members of the staff of that Establishment. Owing to two misunderstandings, each slight in itself, your report (March 29) of my remarks suggests in effect that no such opportunities are allowed. This is so manifestly unfair to the Scientific Civil Service, to which I belong, that I hope you will correct the impression. You quote me as saying that "post-graduate education was limited to courses in engineering drawing and electronics and to evening classes on such subjects as statistics." The subjects are correct but I was referring only to special courses for graduates at the R.A.E. Technical College. You also quote me as saying that "Scientific officers were unable to undertake full-time studies for higher qualifications." Immediately following a remark that we do encourage and help our scientific officers to get doctors' degrees by thesis, my impression is that I said that "on the other hand, we do not encourage part-time study for masters' degrees."

I can hardly ask you to allow me to supplement my remarks at the Conference by including in this letter any details of the post-graduate opportunities which are open to our Scientific Officers, but I do assure you, and your readers, that they are quite considerable.

H. A. METTAM,
Technical Training Officer.
Royal Aircraft Establishment,
Farnborough.
April 5, 1957.

REVERSING GEAR

SIR,—In your leading article entitled "Gas Turbine at Sea" (THE ENGINEER, October 19, 1956), I was particularly interested in the reference to "... the well-known problem of reversal with a gas turbine drive . . . solved by the use of a reversible pitch propeller." May I put forward an alternative solution ?

The power requirements for any shaft can be met by any number of prime movers. I suggest that in the case of high-speed prime movers required to power a shaft of relatively low speed two prime movers could be used, driving the shaft through a differential gear. Thus the shaft speed would be proportional to the speed difference between the prime movers; stepless variation and simple reversal would be inherent in the system.

Applied to marine gas turbine drive, I visualise the installation and operation of the system somewhat as follows. Turbines A and B, lying respectively to port and starboard of the propeller shaft, would be geared to a common differential whose output shaft would drive the propeller shaft through a dog or other non-slipping clutch. The engaging gear for this clutch need be no more complicated than the present turning gear. In preparation for movements turbine A would be started up and set to its lowest running speed, the clutch being disengaged. Turbine B would then be started and set to the same speed as turbine A, when the differential output speed would be zero and the clutch could be engaged. The propeller shaft could now be turned "ahead" or "astern" by giving turbine A more fuel than turbine B, or vice versa. There would be no need to start, stop or reverse either turbine during manœuvres, and for steady running the necessary speed difference would be maintained, in effect, by suitably setting the turbine governors.

Such a system might also be used with steam turbines, eliminating the present astern blading and reduction gearing, and also for main diesel engines which could be made without reversing gear. In the case of the relatively slow-speed diesel, a step-up gear would be necessary between the engines and the differential unit. A further application is in the field of diesel locomotion, where high torque is required at very low rail speeds, and recourse is now made to such compromise media as electrics, hydraulic torque converters and slipping clutches.

I trust that these thoughts will be of interest.

D. GUTHRIE
14, Heath Halt Road,
Heath, Cardiff,
April 15, 1957.

Literature

The Specification and Management of Materials in Industry. By C. H. STARR, A.M.I.Mech.E. Thames and Hudson, Ltd., 30, Bloomsbury Street, London, W.C.1. Price 21s. net.

LIEUT.-GENERAL SIR THOMAS HUTTON, Director of Productivity Council, says in his foreword to this book that while much attention has been devoted to production control, "unfortunately less thought has been given to the materials with which every production process starts," and he proceeds to suggest that "this book will do much to stimulate thought on this vital subject," and we are in full agreement with both statements. Many managements would be shocked if they were brought to realise how much capital was locked up in material that would never be used. The book before us shows how savings may be made by paying more attention to a somewhat neglected subject, and accordingly we are advised to set up a central authority to handle it.

The first chapter is introductory, in which the author points out that in dealing with materials he excludes purchased articles, such as forgings, &c., but it is doubtful if this is wise and whether it is not more logical to work under three headings, material, labour and factory expense. The necessity for management to take a more definite interest in the materials position is rightly stressed. In Chapter II we are given a few simple illustrations to indicate some of the problems experienced in selecting the most suitable materials and how these problems can be met, and also the necessity for having appropriate specifications. Chapter III makes a good case for setting up a central materials authority, as well as the need for having everything established on a definite and predetermined basis, with a view to the elimination of waste. The same theme is further developed in the following chapter and the possibility of utilising the services of an outside consultant is discussed. In Chapter V the value of purchasing specifications is considered, as far too often the attention paid to this is very casual, for the price of an article may be seriously enhanced by a specification that is unnecessarily rigid; it is further suggested that what might be thought to be less important items should still be governed by an appropriate specification. The technical side of purchasing receives attention in Chapter VI, where it is pointed out that there is frequently friction between the purchasing and engineering sides of a factory which has led to some firms putting an engineer in charge of the actual purchasing, though often this has not proved successful in that finance does not appeal to most engineers. It would be better for cordial relations between different departments to be fostered, and the means of ensuring this is largely the theme of Chapter VII, while it cannot be stressed too much that it is essential for the functions of each department to be clearly defined. The organisation of a materials department is dealt with in Chapter VIII, where a family tree shows the proposed layout, but we should like to have been told what size of factory the author has in mind. It is very doubtful whether Mr. Starr is wise in having chemists and metallurgists in his materials department, for it is normally more economical and efficient to have a centralised metallurgical department for the whole factory. Chapter IX is devoted to the inspection of material, the author advocating the centralisation of inspection, but here must be considered the nature of the material, for some undoubtedly will have to be inspected by the metallurgist. The extent to which Government specifications and national standards can be utilised is discussed in Chapter X, and it is rightly pointed out that "they cannot be used without careful reading and study in each case." Though they cannot be placed in unskilled hands they may be of great help if properly applied. In Chapter XI the author advocates the intelligent use of approved suppliers' lists, though unless great care is exercised we feel there may be a serious danger of avoiding competition, resulting in the payment of more for the material than is justified. How components and purchased parts should be dealt with comes under review in Chapter XII, and it is felt that Mr. Starr is right in maintaining that all components should pass through the materials department. Otherwise there is a danger of "falling to the ground between two stools." A very debatable subject is raised in Chapter XIII and that is whether processes should be governed by a specification, processes such as electrodeposition, heat-treatment of metals,

mixing of varnish, &c., and in spite of what the author claims it is suggested that this is hardly a matter for the materials department to undertake. Chapter XIV deals with the different systems of numbering and for materials it is agreed that a very simple one should suit the requirements. The author strongly recommends separating the engineering aspect of materials work from those other interests in materials which are the concern of the purchasing and accounting departments. When considering the question of how to write purchasing and process specifications (Chapters XV and XVI) stress is laid on the necessity for using simple language, and also for making them no more stringent than is required. Too often the tolerances and limits demanded are made too exacting, leading to unnecessarily high costs. It should be remembered that a process specification may be read by the less educated in the works and accordingly it should be written in simply understood language and be free from ambiguity. Chapter XVII describes the conduct of a materials engineering office ; as the author rightly contends that much has been written regarding big undertakings, on account of which he confines himself to the small office, and by carefully considering some of his suggestions pitfalls may be avoided. The running of a materials engineering laboratory and the equipment necessary form the subject of Chapter XVIII, but as has already been suggested, it is considered preferable for all the work required by the materials department to be undertaken by a centralised metallurgical section for the whole works. Finally the important question of personnel is examined in the concluding chapter (XIX) and we are glad to find an engineer in charge, whereas too often a non-technical man is appointed. If the staff is in accordance with Mr. Starr's proposals a good team should result. The book concludes with two useful appendices, one giving examples of typical specifications and the other dealing with statistical methods.

This book on a subject hitherto neglected will be found to be useful by all managers who wish to see their materials department organised on economical and businesslike lines.

The General Theory of Electrical Machines. By BERNARD ADKINS, M.A., M.I.C.E. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

THIS is an advanced textbook and is so planned as to lead the student from those general principles and methods of analysis that are common to all kinds of electrical machine to the nature and performance of particular machines. These include conventional d.c. machines, crossfield generators and d.c. machines used as amplifiers in control systems, both synchronous and induction a.c. machines, a.c. commutator machines, alternators with cylindrical rotors and with salient poles. Even to understand the opening chapter the student must already be familiar with the general theory of electrical machinery ; he must have a good knowledge of specific features in the design of the commoner type of machine ; he must, in short, have reached degree standard in electrical power engineering. Having this background, the systematic treatment found in this book for more advanced subjects will be of great value to him. There is discussion of steady state and transient conditions, of oscillations and damping, of short-circuit conditions, of performance during starting, of the negative phase sequence reactance, of power system analysis, and of many design details. The treatment is mathematical throughout, but the mathematics is far from recondite. No more is needed for its understanding than a little knowledge of differential equations and some familiarity with the Heaviside operational calculus. It is true that the formulæ are often complicated and puzzling. But this is not because they express difficult relations. It is because of the large number of independent terms that occur in the solution of problems concerned with electrical machinery.

One of the merits of the book is that the systematic treatment of the subject found therein reveals hitherto unsuspected similarities between different kinds of machines that are more often supposed to have little in common. Here one realises that any particular type of machine, even any particular kind of performance of a machine, is no more than a special case of a generalisation that is wide enough to apply to all rotating electrical machines. This basic unity is most clearly demonstrated in the last chapter, which is entitled " The Generalised Rotating Machine." It is shown there that the equations for all kinds of rotating machine can be expressed in the same form. This is that of a matrix multiplication.

As an introduction to systematic thinking, matrix algebra has some educational value and is therefore in place in the book under review, but as a practical tool in engineering it only serves those well who use it every day and for months on end. The nature of matrix algebra is often misunderstood and it is, in consequence, regarded with far more awe and reverence than it deserves. People seem to think that, like, say, Bessel functions, matrix algebra expresses unfamiliar mathematical relationships. But it does nothing of the sort. It is really only an unfamiliar notation for the very simple relationship of simultaneous equations. In a matrix a pigeon-hole is allotted to each quantity that occurs in a set of simultaneous equations and it is thereby ensured that no quantity shall be overlooked. This methodical notation must, however, be learnt and one has to be conditioned to its use by frequent practice or one may all too easily make the mistake of putting quantities into the wrong pigeon-holes.

To sum up, this book will be a valuable reference work for those who have to solve intricate problems in machine design and the performance of machines and networks, and it will contain some useful and stimulating thoughts for those who have to teach electrical power in universities and technical colleges.

Books Received

The Mechanism of Phase Transformations in Metals. Institute of Metals, 17, Belgrave Square, London, S.W.1. Price 50s.

Aircraft Hydraulics. Vol. I : Hydraulic Systems. By H. G. Conway. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 35s.

Foundations of Wireless. By M. G. Scroggie. Sixth edition. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 12s. 6d.

Protective Painting of Structural Steel. By F. Fancutt and J. C. Hudson. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 21s.

American Civil Engineering Practice. Volumes I and II. Edited by Robert W. Abbett. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 120s.

A First Year Engineering Drawing. Fifth edition. By A. C. Parkinson. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 9s.

Television Engineering Principles and Practice : Waveform Generation. Vol. 3. By S. W. Amos and D. C. Birkinshaw. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 30s.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

STEEL LINKS AND STRAP ASSEMBLIES FOR LIFTING ATTACHMENTS FOR PACKING CASES

No. 2837 : 1957. Price 5s.—The standard provides for seven classes of links and strap assemblies having a range of safe working loads from 4 cwt to 5 tons. Some general guidance is also given on the methods of applying these assemblies to the packing case.

IRON AND STEEL FOR COLLIERY CAGE SUSPENSION GEAR, TUB AND MINE CAR DRAWGEAR AND COUPLERS, AND ROPE SOCKETS, PART 3 : 1·5 PER CENT MANGANESE STEEL CASTINGS FOR MINE CAR COUPLERS

No. 2772 : 1957. Price 3s. This specification is part of a general revision of British Standards for iron and steel for colliery haulage and winding equipment. It specifies the requirements of the mining industry in respect of 1·5 manganese steel castings for mine car couplers. The requirements for chemical composition and for mechanical properties have been selected after careful consideration of the particular conditions to which the couplers will be subjected in service, and every precaution has been taken to ensure that couplers manufactured from this material will give the greatest possible protection to those employed in the mines. Appendices include the recommended dimensions for the standard preparation round tensile test piece and the procedure for welding.

PARALLEL SCREW THREADS OF WHITWORTH FORM

No. 84 : 1956. Price 10s.—This revised standard gives tables of basic sizes, limits and tolerances for British Standard Whitworth (B.S.W.) and British Standard Fine (B.S.F.) screw threads. It includes a new feature in a " selected thread " series of recommended diameter-pitch combinations, the table for which follows very closely the corresponding table in B.S. 1580 : " Unified Screw Threads." This series is for use in applications where the standard coarse (B.S.W.) and fine (B.S.F.) pitch series have insufficiently fine pitches. It will frequently be more suitable for use than the B.S. pipe parallel thread series in new designs where an extra fine pitch thread is required.

The British Standard pipe parallel thread series was incorporated in B.S. 84 : 1940 for fine threads for general engineering purposes and though this series was not intended for pipe joints it has been extensively used on certain kinds of pipe fittings, where the pressure seal is not made on the threads. This has caused some confusion with the pipe threads specified in B.S. 21 (" Pipe Threads "), where the pressure seal is, in fact, made on the threads. It has therefore been decided to publish the tables of basic sizes, limits and tolerances for the British Standard pipe parallel thread series given in B.S. 84 : 1940 in a new standard, now in course of preparation and which will include recommended limits and tolerances for all B.S.P. threads, whether or not the pressure seal is made upon the threads.

In revising the present standard advantage has been taken of the experience gained in the use of B.S. 84 : 1940 to modify it to conform to modern thread tolerancing practice. Thus an allowance (minimum clearance) is provided on certain classes of bolts of sizes up to and including $\frac{1}{4}$in diameter ; the recommended associations of classes of bolts and nuts include nuts having larger effective diameter tolerances than the corresponding sizes of bolts. Three classes of tolerance are provided for bolts : close, medium and free. The allowance provided on bolts in the medium and free classes is by reducing the maximum bolt limits below basic size. The purpose of this allowance is to provide for the threads to be plated, if necessary, the plating encroaching within the allowance ; it also guarantees easy assembly of maximum metal bolts and nuts, thus facilitating the use of torque wrenches. The two classes of tolerance for nuts are recommended—medium and normal—and are similar to the old medium and free-fit nuts respectively. The old close-fit (now termed close class) nuts are now regarded as non-preferred but, in view of their usage in the past and for special needs, their limits and tolerances are given in an appendix to the standard.

All screw threads made in accordance with this revised standard will assemble with the corresponding nominal sizes of mating screw threads made to B.S. 84 : 1940. No change has been made in the general three-part formula used as a basis for tolerancing effective diameters, and the formulæ used for tolerancing the other thread elements also remain unchanged from those in the previous specification in order to minimise any changes in the sizes of the gauges used to control the size of the finished work.

Construction of Secondary Treatment Plant at the L.C.C.'s Northern Outfall

Construction of a diffused air plant to treat about 60 m.g.d. of settled sewage is now at an advanced stage of construction at the London County Council's Northern Outfall. The repetitive nature of much of the concrete construction has led to the use of elaborate shuttering gantries, which, with other aspects of the constructional work, are described.

TWO years ago the London County Council brought into use a set of sixteen primary sedimentation tanks at the Northern Outfall works at Beckton, where sewage from a large area of North London, giving a dry weather flow of 180 to 200 m.g.d., is treated and discharged into the Thames. At that time we published* an account of the L.C.C.'s plans for improving sewage treatment at the Northern Outfall, which involve an expenditure of the order of £8,000,000, and an explanation of the new and existing installations. The primary tanks then completed are of sufficient capacity to treat the entire dry weather flow, and we understand that they have given very satisfactory service since that time. A secondary treatment plant intended to purify about 60 m.g.d. of the settled sewage from the primary tanks, using the activated sludge system, was also under construction at that time. It has now reached a fairly advanced stage, and some details of its construction are described here.

The effluent channel from the primary tanks leads to a penstock chamber where part of the flow can be diverted to the aeration channels of the new plant. There are six sets of aeration channels, with eight channels in each set, laid out to form a large rectangular area with the supply channel running down the middle, and three aeration sets on each side of it. The accompanying illustrations show the present state of construction.

Flow of sewage in and out of the channels, supply of activated sludge, compressed air, and so on, is all controlled from an operating gallery running along one "long" side of the rectangle which has all the various main channels grouped below it, all extending along its length to serve the six sets. The treated sewage then flows to fifteen circular settling tanks, each 110ft in diameter. Sludge is drawn off, and the settled effluent flows to the river. The design of the plant is of no little technical interest, involving, for instance, provision for stepped and tapered aeration. However, it is not our intention to describe these aspects of it in the present article, which concentrates on the constructional work.

* THE ENGINEER, July 1, 1955.

Construction of a gas turbine power station and sludge mains and digestion plant is also involved in the general scheme.

Excavation and Piling

In our previous article we briefly described the concreting plant and pile casting yards for the secondary treatment plant. All of the main structures, together with adjacent pipework, are carried on reinforced concrete piles; 10,500 piles were cast on the site. They were 14in and 12in square and varied in length from 17ft to 51ft. Piles were driven from two piling frames, one 50ft and the other 40ft high, and also a 38 R.B. with hanging leaders which was capable of driving a pile 50ft in length. The two piling frames worked in the area of the aeration channels, main supply channel and operating gallery. The circular settling tanks and other adjacent culverts were all driven by the 38 R.B. as this was more suitable for pile driving in circular work.

Excavation was carried out immediately after the completion of pile driving. The volume excavated was approximately 100,000 cubic yards. This excavated material is now being returned from the spoil tips and with a quantity of 50,000 cubic yards of imported fill will form the permanent embankments and filling around the concrete structures.

Reinforced Concrete Construction

After completion of the piling and excavation, a heavily reinforced raft of concrete was laid over the entire area of the aeration channels, which extends over very roughly 400ft by 850ft. The walls of the channels themselves were then constructed on the raft. In building these walls, and also the somewhat similar work of building the side walls of the supply and effluent channels, and of the circular walls of the sedimentation tanks, a great deal of repetition was involved. The work therefore lent itself to construction with rail-mounted shuttering gantries—two designs for the work in the aeration channels, one for the supply and effluent channels, one for the circular tanks, and some smaller ones for other works. These shutters form one of the main points of interest, and we describe them in greater detail in the next section of this article.

The total volume of reinforced concrete on the contract, excluding that in the precast piles, is approximately 70,000 cubic yards. There are two stations for batching and mixing. One feeds a 1 yard mixer and delivers concrete into a 6in concrete pump. This plant has constructed the whole of the aeration channels and main supply channel, and has supplied dumpers taking concrete to some of the more isolated portions of the site. The second concrete plant consists of a weigh batcher supplying two 14/10 mixers, one of which feeds into a 4in concrete pump and the other into dumpers.

Three different cements have been used on the contract. All piles and all work below the level of approximately 8ft below ground level were constructed in sulphate-resisting cement. Portland cement is used on the main construction but where progress depends on the early striking of shuttering rapid hardening cement is used.

The concrete mix used is 1 : 1½ : 3½, with a specified crushing strength of 2200 lb at seven days and 3300 lb at twenty-eight days. Strengths measured over the past twelve months have averaged about 3200 lb at seven days. The areation channel wall shutters can be struck (this case is the most intricate because the walls splay out) when the concrete reaches a cube strength of about 1000 lb per square inch, which, we are informed, with a low water cement ratio and using rapid hardening cement, is usually achieved in sixteen hours. Cubes are crushed on the site for this purpose, and also at the County Hall, for routine quality control of the concrete. Another aspect of the concrete work is that all surfaces exposed to the sewage, or visible upon completion, are finished with a smooth face, and items were included in the bill of quantities for finishing concrete to a very smooth surface. The specified surface finish has been achieved in the main by using steel shutters for pours of the full wall height, and paying attention to the quality of the concrete and, in particular, the vibrating process.

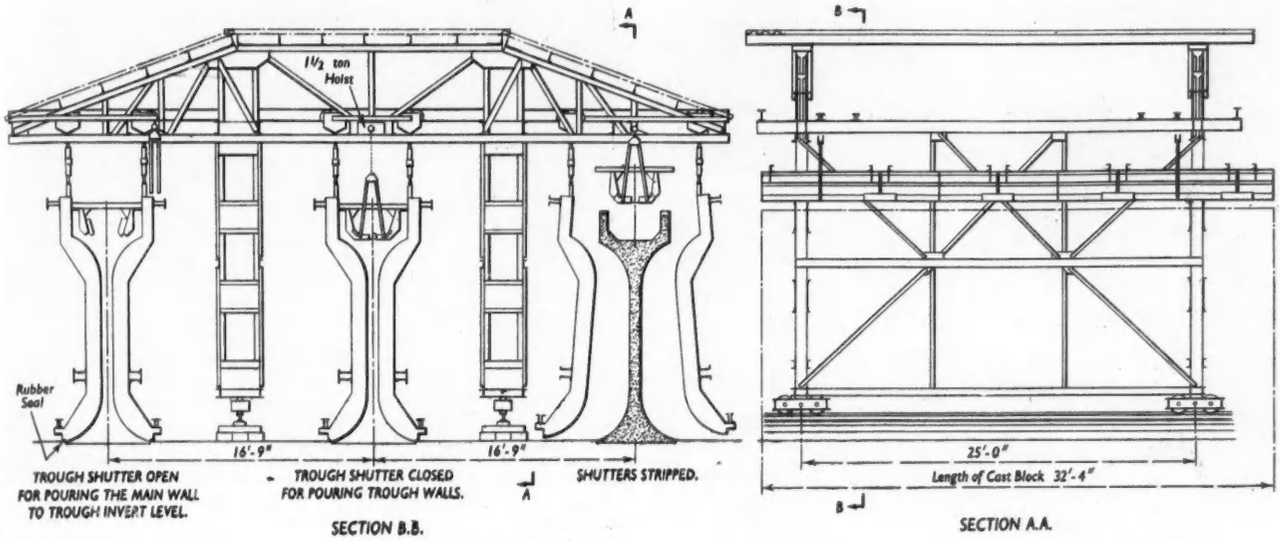
Travelling Shutters

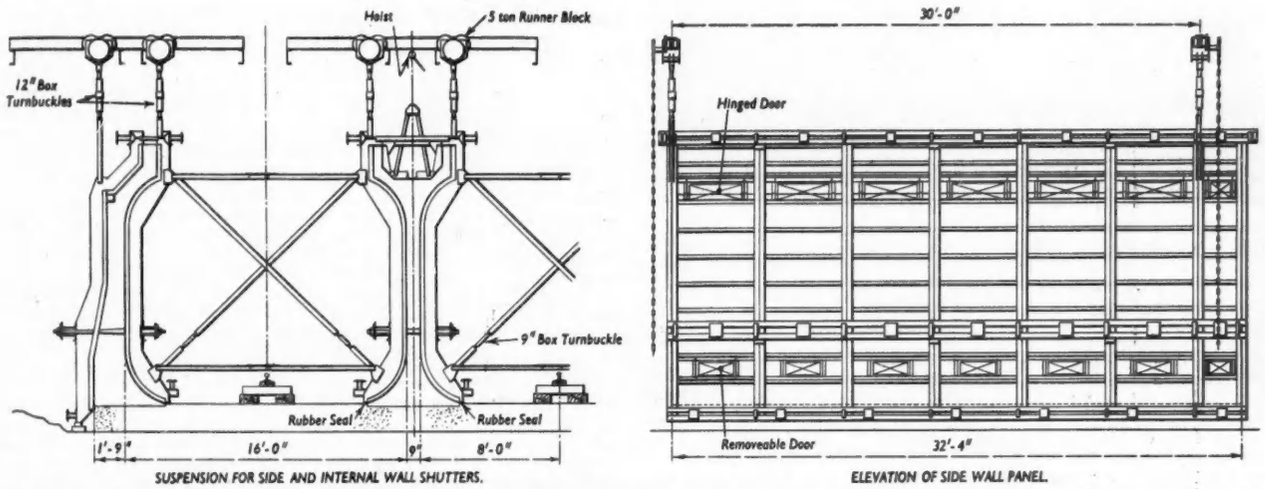
On jobs where the concreting work is largely repetitive, the shuttering can be an important factor in the rate of progress achieved. The diffused air plant illustrates this class of work very well. Furthermore, the magnitude of the work has justified the use of somewhat elaborate shuttering plant.

The aim of the shuttering design was to concrete, in each case, the full height of the wall in one lift, and to design for a complete cycle of use every twenty-four hours. The principal gantries are also roofed over, to allow the work to be continued under adverse weather conditions.

For building the walls of the aeration channels,

(Left) Final settling tanks. Mixed liquor is led to the central diffuser cylinder of each tank by underground culverts, one of which is shown under construction. The clear liquid spills into a circular channel carried in the cantilevers. (Right) Part of the aeration channels. The new primary treatment tanks are in the background, and the penstock chamber which will control flow to the aeration channel can be seen in the centre. At present effluent flows along the channel to the left



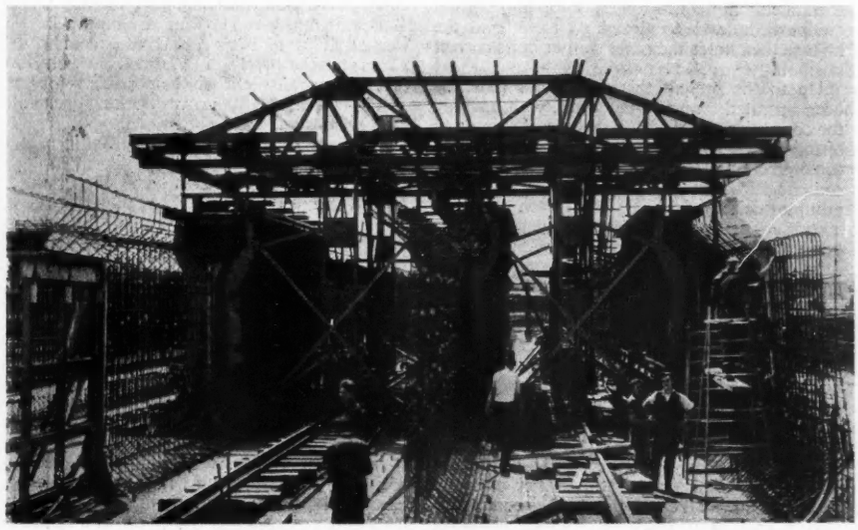


Three 32ft lengths of wall are constructed to the full height of almost 15ft, in one set-up of the gantry and shuttering assembly shown in this drawing. Generally, a forty-eight-hour cycle of concreting, striking, moving and refixing has been maintained with it, but a twenty-four-hour cycle of operations is feasible

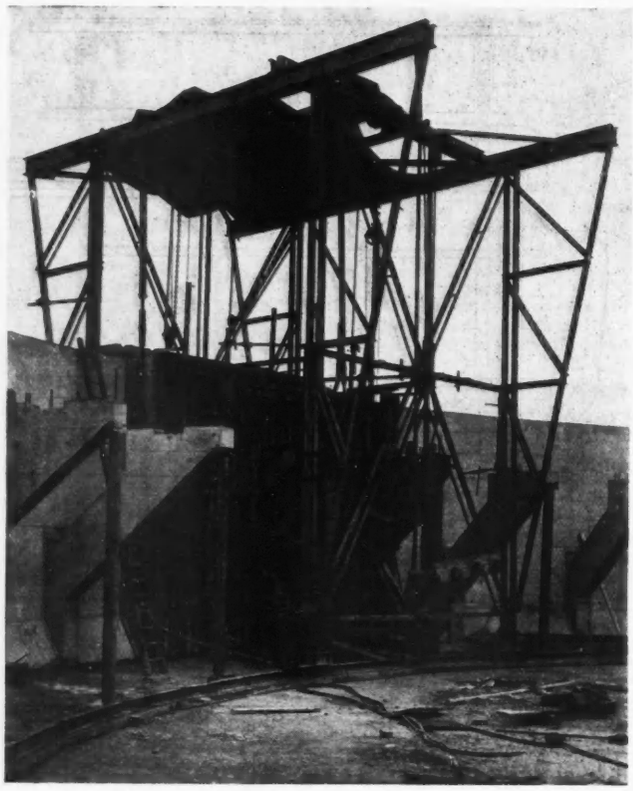
two gantries are in use. These channels, it will be recalled, are 390ft in length, and are all about 15ft in depth. They are divided into six sets. Each set comprises eight channels, covering a width of 140ft and arranged so that the sewage flows up and down the eight channels over a total length of about 3000ft whilst it is being purified by the aerobic bacteria which the process utilises. The baffle walls between the channels do not have to resist unequal hydrostatic loading, and so they are only 9in in thickness; at the top, however, they splay out to form a walkway with a channel for compressed air mains below it. There are thus nine walls—seven " baffles " and two outside walls—in a set of channels.

The main shuttering gantry concretes three walls at one set-up, over a length of 32ft, and for the full height of 14ft 3in the total volume of concrete being about 65 cubic yards. It is shown in the drawing and also in the illustration on this page. The six shutters in use at any one set-up have an area of 375 square yards, and are hung from a steel gantry which travels on four sets of twin bogies, propelled by hand winches. The complete gantry weights 60 tons and is roofed. The shutters are handled by chains and pulley blocks as can be seen in the illustration.

The gantry was designed so that, structurally, it would be isolated from the shutters themselves, when they were in use ; the aim was to avoid transmitting vibrations from the concrete pump to the shutters, for all concrete is pumped to distributing chutes on the working platform. Thus the shutters are not strutted from the gantry. Each shutter is a steel panel of all-welded construction. A typical panel is shown in the drawing, giving an idea of the stoutness of construction needed to limit deflections for a pour of almost 15ft. There are doors in the lower part of the shutter, through which immersion vibrators can be inserted when the splay at the bottom of the walk is being concreted. When concreting has progressed, these doors are closed, and the immersion vibrators are used from the top. The vibrators have heads only 1½in in diameter, since the space inside the shutters, allowing for a double mesh of reinforcement, is limited. When the concrete is nearly to level, the doors of the trough shutter are closed ; when open these doors act like a chute, and when closed form the bottom of the shutter, as can be seen from the drawing. Only one



Principal shuttering gantry for constructing aeration channel walls. An early stage of the work is depicted, and the roofing of the gantry has not been completed



Gantry for shuttering the walls of the secondary sludge tanks. The full height of wall over about 20ft of length, together with two cantilever arms, is concreted in one operation. The concreting cycle is daily

line of bolts passes through the concrete of the wall; these bolts are at 5ft centres along the line of the centre of pressure of the wall. They are formed with shoulders so that they bear on the inside wall of the shutter, and form a distance piece as well as a tie. The shutters are also tied at the top, above the concrete level, and upthrust is resisted by bolts screwed into nuts which were cast in the substructure concrete, and bearing on steel channels at the base of the shutter.

For striking, use is made of the fact that the shuttering panel hangs out of plumb, as the drawing shows. The special spacer bolts are removed, one by one, and replaced by bolts with wing nuts. Thus, as the wing nuts are slackened, so the shutter gradually frees itself, by virtue of its own weight. When fixing, the central pair of shutters is first plumbed. Then the angle framework locates the outer shutter; the "cranked" horizontal angles at top and bottom are pushed down to straighten them, and the linkage then holds the outer shutter in its correct position.

Up to the present this gantry has generally been operated on a two-day cycle, with one day for concreting and one for striking, moving and setting up. Twelve set-ups would be needed to complete a group of three channel walls, but so as to allow the gantry to be moved from one group of walls to the next, only eleven pours are constructed. The gantry is then jacked up, its bogeys are turned through 90 deg., and it is moved to the next "run." Where an end wall has to be built, a special shutter is hung from the appropriate position; one of the end shutters is shown in the drawing.

The end bays, together with the outside walls, are constructed with a separate travelling gantry which has constructed half the outside wall pours (these walls have been built missing out alternate set-ups to allow shrinkage of the "green" concrete) and is, at present, being modified to enable the last bays of the main walls to be constructed. This gantry will shutter one wall at a time and will then lift the shutters completely over the constructed work, travel back and shutter the next wall. It is anticipated that this operation will take three to four days. The gantry is similar in the general principles of its construction to the gantry just described, but has a greater height to lift the single shutter over the completed work. Work on the aeration channel walls started in November, 1955, and was programmed to finish in February, 1958. Actual progress has been better than planned and completion of the walls is now expected in October of 1957.

Shuttering the Circular Tanks

Two similar shuttering gantries are also in use for building the circular sedimentation tanks. Each tank is 110ft in diameter and 13ft deep, and there are fifteen tanks altogether. Effluent from the tanks will flow over a double weir into a channel which consists of precast concrete elements carried by cantilevers springing from the tank walls. The tank is built in eighteen set-ups of the shutter, each one including two cantilevers, and extending for the full height of the tank. The area shuttered is about 70 square yards, and the cycle is a daily one for striking, moving, refixing and concreting.

Construction of the last pour of a tank wall with one of these gantries is shown in the accompanying illustration. The shutter is plumbed from the previous work. The substructure concreting necessitated leaving an accurate "starter" wall, which served as a guide both for screeding the tank bottom and positioning the wall shutter. In this case the gantry is again roofed, and has sufficient height to lift the inner shutter clear of the work. Again, there is only one line of bolts—"spacer" bolts—passing through the wall, at about the level of the base of the cantilevers. The shutters for the cantilevers are lowered by a lifting cradle, which can be seen in the illustration, and fastened to the wall shutter with channels and bolts. The cantilevers remain propped when the shutters are struck.

The supply and effluent channels are both of similar cross section and once again construction of their walls lent itself to the same general method. The effluent channel is 1200ft long by 20ft wide by 10ft deep, and the supply channel is about 600ft long. Both walls are poured at one set-up, over a length of about 30ft and for the full height, the four shutters again being hung from a gantry. The quantities in one set-up are 18 cubic yards of concrete and 150 square yards of shuttering. These shutters are smaller and simpler than the ones just described, and the panels are formed from an assembly of standard 4ft by 2ft steel forms.

A similar, but much smaller, travelling shutter is in use to concrete the "ridge and furrow" inverts of some of the aeration channels; in this case two uses daily are being achieved. However, construction of the concrete work in the region of the operating gallery was not sufficiently standardised for such a method. For the complex arrangement of channels, pipework and so on in this part of the work, which includes the substructure of the pumping station and control house, more conventional timber shuttering is employed. The operating gallery is about 1000ft long, 50ft wide and 25ft deep.

The entire programme of new works at the Northern Outfall is the responsibility of the engineering staff of the London County Council, under the direction of the chief engineer, Mr. J. Rawlinson, M.I.C.E. The main contractor for the work described in this article (i.e. construction of the diffused-air secondary treatment plant) is Richard Costain, Ltd., and the consultant for the design of the shuttering is Mr. C. Parry, M.I.C.E.

Progress of Potters Bar Railway Tunnel

WE have received from British Railways some details of the progress of the tunnelling works now in progress at Potters Bar, on the East Coast main line, about 12 miles north of King's Cross. It is expected that the whole of this scheme will be completed by the end of 1959, when there will be four or more tracks over the 22 miles of main line route from King's Cross to the Welwyn Viaduct. When four tracks are available it will be possible to operate more trains and improve working generally over this busy section.

The first stage of the scheme, including a new station at Potters Bar, was completed in 1955. The works now in progress or to be carried out include the driving of three new twin-track tunnels; the widening of the existing cuttings on the down side of the line; the reconstruction of a span of the road bridge and improvements to the station at Hadley Wood; and the construction of a new 42in drainage aqueduct to replace an existing structure. In addition, Greenwood signalbox will be abolished and colour light signalling and track circuiting installed.

Four of the six new tunnel portals have now been completed and tunnelling has begun, driving from the south end of Potters Bar tunnel. Considerable progress has also been made in widening the cuttings to accommodate the two additional tracks, which will link with the existing four tracks to the north and south of the works.

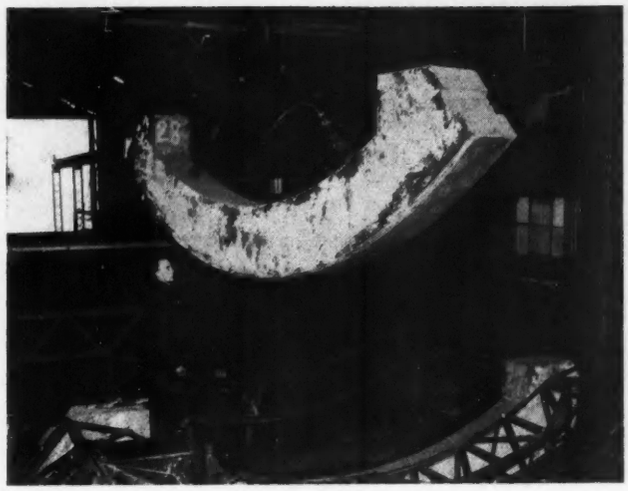
Tunnelling Works

The actual tunnelling works consist of duplication of the three existing tunnels, with lengths as follows:—Hadley South tunnel, 383 yards; Hadley North tunnel, 232 yards; Potters Bar tunnel, 1208 yards. The tunnels are to be shield-driven, mainly through the London clay; compressed air working will not be necessary. An innovation for railway work lies in the use of interlocking precast concrete segments for the tunnel lining; this aspect of the work is referred to below.

A tunnel shield has been erected at portal No. 5 at the south end of Potters Bar tunnel, which is now being driven. All the new tunnels will be parallel with the existing tunnels and are to be 26ft 6in in internal bore, which will allow sufficient clearance for overhead electrification in the future. The external diameter of the tunnel and shield is 31ft.

So far some 30ft of tunnel has been driven and lined with cast iron segments bolted together and pressure grouted. This system of lining the tunnel is to be used at the ends of the tunnels, where there is little overburden, and also to form a temporary extension of bolted-on sections outside the tunnel mouth, to butt against a specially prepared abutment built to resist the thrust of the shield.

The extended lining butts against five king-posts, which are steel box piles, stayed by large walings wedged against a row of sheet piling driven into a "dumpling." Spoil is removed by bucket and crane, through an aperture left in the crown of the extended lining outside the tunnel. The tunnel shield, and one of these abutments, are shown in the illustrations.



(Left) Steel kingposts, walings and earth dumpling to take the thrust of the tunnel shield at the portal. The existing wing wall is to be removed. (Right) Lifting a reinforced concrete tunnel invert segment from one of the seven casting bays. These segments are about 20ft in length and are some 4½ tons in weight

When the work has progressed clear of the portal, the temporary abutment will be removed, allowing free access. The portal will later be faced with Hollington stone. Removal of spoil will then be by conveyor to a hopper loading point over the light railway serving the job.

The tunnel shield in use is about 150 tons in weight and has four galleries. A second shield will drive from the north end of Potters Bar tunnel, and later on a third shield will drive the Hadley tunnels.

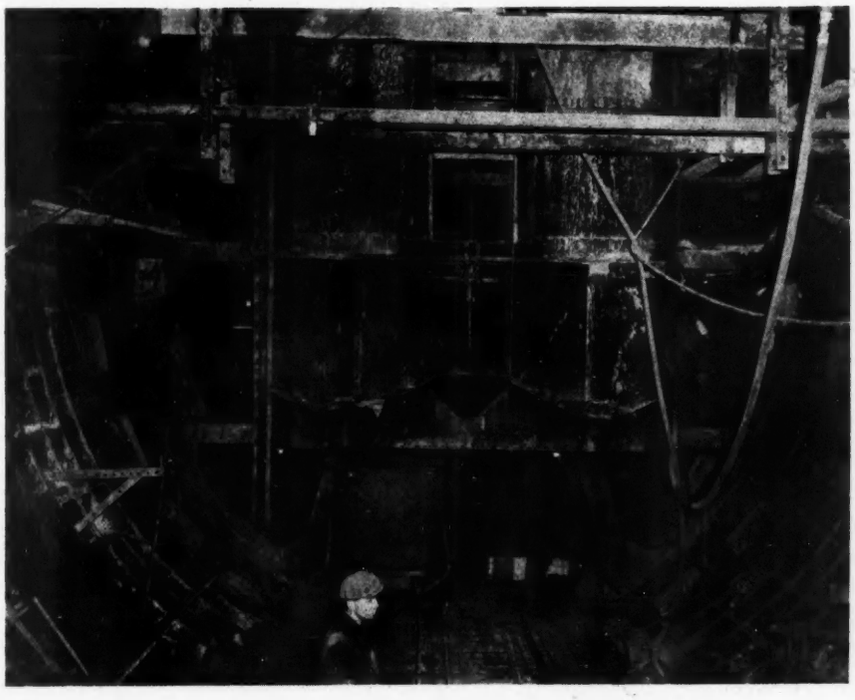
Precast Concrete Tunnel Lining

When a sufficient length of the tunnel bore has been driven and lined with cast iron segments, the tunnel lining will subsequently be formed of interlocking concrete segments. The segments are precast, and are placed in the tunnel in direct contact with the earth. No grouting or bolting is used. It is pointed out by British Railways that the Potters Bar tunnel will be the first tunnel in Britain to be lined in this way. However, the method resembles the recently developed technique in use on several of the Metropolitan Water Board's deep tunnelling works, where unbolted concrete segments have been used to line the tunnels. This work has been described in The Engineer of February 2, 1951, and February 25, 1955.

Each concrete tunnel lining ring will consist of an invert weighing about 4½ tons (one of which is illustrated), with three interlocking segments on either side, forming the lower half of the ring. The upper half of the ring is formed of thirteen segments, six being erected on either side and held in position by mechanical erectors until the centre or key segment is positioned by a central erector fixed to the rear of the shield. The upper half of the ring is then jacked away from the bottom half, forcing the ring against the earth of the bore, and the resulting space between the upper and lower halves of the ring is filled with a dry concrete mix, to form a complete interlocked ring.

The segments of the ring are interlocked with each other and, in turn, each ring is interlocked with the next. This is achieved with recesses and nibs on the faces of adjacent segments. Two faces of each segment are recessed and two faces have nibs which fit the recesses. The lining segments are cast in concrete made with an acid-resisting cement. Special segments are cast for the tunnel rings which have to accommodate refuges in the tunnel walls and for the apertures for the two ventilation shafts.

A factory has been erected to manufacture the concrete tunnel lining segments. It consists of two production sheds with a common batching plant. The batching plant feeds the aggregate to a separate mixer in each production shed by conveyor belts. One shed makes reinforced concrete inverts and the other the remaining tunnel lining segments. In the "invert" shed a normal Portland cement concrete mix is used. This shed is equipped with seven steel casting bays laid transversely along its length, each with capacity for casting seven inverts. The whole length of the shed, and an area outside, is served by a 10-ton overhead travelling crane. In all, some 3500 inverts and about 68,000 other lining segments will be produced for the tunnels, and it is expected that they will be completed by about the end of 1958.



The tunnelling shield at the south end of Potters Bar. It weighs about 150 tons. Spoil removal will later be by conveyor belt fixed to the rear of the shield

Other Works

In all, about 750,000 tons of spoil from the cuttings and the tunnel bores will be excavated and carried on the site railway to the tip.

Widening of the cutting in the 750 yards between Hadley North and Potters Bar tunnels is almost complete. The earthworks have been carried out by draglines and bulldozers and the cutting slope was graded 1 in 4 as a first stage "initial" cut. During the second operation drainage counterforts were cut and the grading of the slope altered. At the counterforts the cutting slope is triple graded from 1 in 2·8 at the top of the slope, falling to 1 in 4 in the middle section and decreasing to 1 in 8 at the foot of the cutting. The slope is also graded longitudinally, the highest point, about midway between pairs of counterforts, is left at the initial gradient of 1 in 4, descending gradually to the triple grading at the counterforts to provide a watershed in both directions.

The down side span of the triple-span road-bridge at Hadley Wood station is being reconstructed to provide room for the additional tracks. A new abutment for the span is nearing completion and shortly the girders of the existing span will be removed and the old abutment will be demolished. The new span will consist of standard precast pretensioned concrete beams. Preliminary work for the construction of portal No. 6 at the north end of Potters Bar tunnel is well advanced and earthworks are in progress. Included in the work to be carried out at this site is an entirely new aqueduct, built alongside the existing aqueduct to avoid any disruption of drainage while the work proceeds.

The works between Greenwood and Potters Bar are being carried out under the general direction of Mr. A. K. Terris, M.I.C.E., chief civil engineer, Eastern Region, British Railways, and Sir William Halcrow and Partners are the consulting engineers. The main contractor is Charles Brand, Ltd.

Manufacture of Fractional Horsepower Motors

A factory for the production of fractional horsepower motors was established by the British Thomson-Houston Company, Ltd., at Newcastle, Staffs, in 1945. *Later an administration block was built to accommodate design, drawing-office and sales staffs. This self-contained factory has an output capacity of more than* 6000 *motors per week ; a new production line to be completed shortly will add about* 2500 *to the weekly output capacity. With its apprentice training centre and training drawing-office the factory is equipped for the practical training of technicians, draughtsmen and craftsmen, and there are facilities for part-time study at the North Staffordshire Technical College, Stoke-on-Trent.*

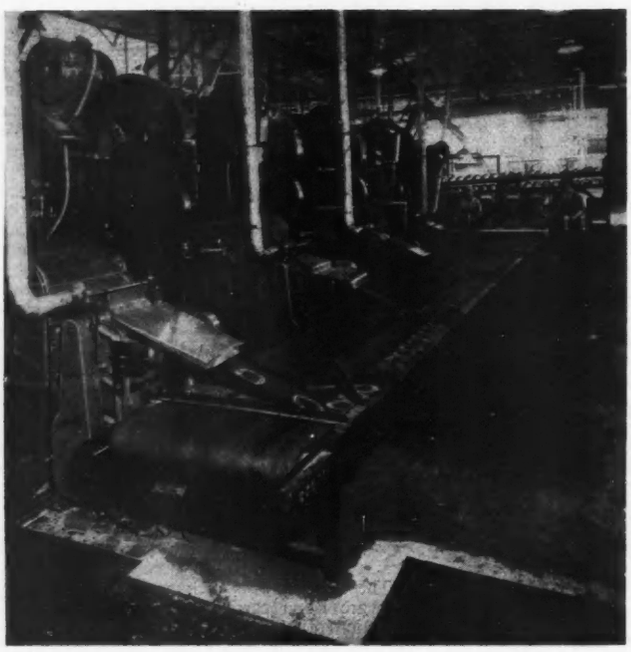
FRACTIONAL horsepower motors have been made by the British Thomson-Houston Company, Ltd., since 1921. In 1945, when the growing demand for these motors had outstripped the existing manufacturing facilities, the company acquired a munitions factory in Newcastle, Staffs, and re-equipped it for the production of fractional horsepower motors. More recently a new office block has been built at the Newcastle works to allow the appropriate design engineering, sales and drawing-office staffs to be transferred from Rugby, so that all the activities involved in the motors made at Newcastle could be concentrated on a single site. Some impressions gleaned from a recent visit to the works are recorded here.

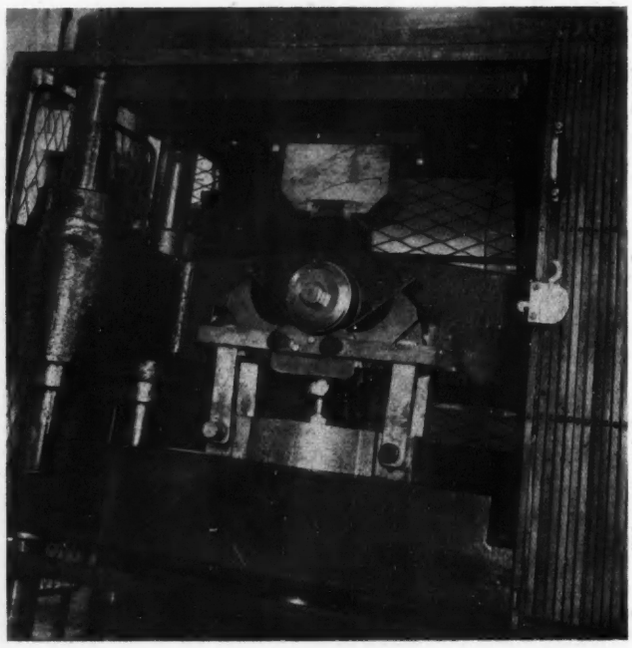
The Newcastle works consists, essentially, of four similar production assembly lines, which are self-contained except that they have a common source of supply for stator and rotor stampings and end shields, as described below. Each of the four assembly lines can produce upwards of 1500 f.h.p. motors per week and a fifth line, which is now being equipped and is due to be in production by the end of May, will have a weekly capacity of 2500 f.h.p. motors. These assembly lines enable the company to plan production of the many types and sizes of motors. It is pertinent to observe, in passing, that despite the manufacturer's efforts towards standardisation, customers' demands call for 9000 varieties of product, differing in ratings, types, sizes and detailed requirements.

The Newcastle works is laid out for the mechanised matched production of the components required for the complete motor, the production of each component being timed to give the required output at the required time.

A good example of the matched production methods is to be seen in the first of the manufacturing processes—the blanking of stator and rotor stampings. Sheets of electrical steel are fed to automatic blanking presses. Two of them are 150-ton, four-gang presses : each produces, per stroke, four stator blanks and four rotor blanks (all unslotted). Here the stator and rotor blanks follow different routes on separate conveyors. The stator blanks are fed to multi-slot presses, where the winding slots are stamped out in one operation, after which any burrs are ground off.

From each of these presses the slotted stampings are discharged in separate streams on to a conveyor belt feeding the weighing stations, which can be seen in the background of Fig. 1. By segregating the output from each press in this way it can be ensured that identically similar laminations are used to build up the stator core of each motor. Since the correct weight of steel in a core is more important than the actual number of laminations, weighing is used to obtain the right size of each core stack ; weighing has the additional advantage of being easier and more consistent than counting. Each weighed stack of laminations is then placed on a rotating jig to align the slots. The stack is then ready to become a stator core by being pressed and





Figs. 1 and 2—(Left) Stator laminations being discharged from multi-slot presses. The output from each press is segregated and weighed at the end of the conveyor belt. (Right) Hydraulic press for wrapping stator shell into cylindrical shape. The press is tilted to facilitate access

clamped into a steel shell, which has been made, in the meantime, on one of two hydraulic presses (Fig. 2) near the weighing station. Welding of the longitudinal seam of the cylindrical shell then completes the stator assembly.

Because the stamping operations tend to impair the magnetic properties of the steel sheet, the stators are taken on a conveyor into a long furnace where they are annealed at accurately controlled temperatures to restore the magnetic properties.

Before the subsequent enamelling process the stator shells are machined in preparation for the fitting of the end shields. From the enamelling ovens an overhead conveyor takes the stators to the winding conveyor, where they are automatically segregated, according to core length, on to the correct conveyor channel, as indicated in Fig. 3.

Lining of the stator slots is done in automatic machines which cut, bend, insert and finish the liners from press-board insulation. The main coils are then wound from enamelled wire directly into the lined stator slots on automatic coil winding machines developed and made by the company. The machines are adjustable to enable them to cope with variations in winding specifications. To complete the stator winding the auxiliary coils constituting the starting winding are inserted by hand, and the connections are made. The wound stators are then inspected and electrically tested for continuity, magnetic symmetry and insulation before being passed through a continuous impregnating and baking oven, where the windings are solidly insulated with a thermo-setting synthetic varnish. The stators are then finish-machined and the cores ground to the specified internal diameter and inspected before being put in storage racks ready for assembly into complete motors as required.

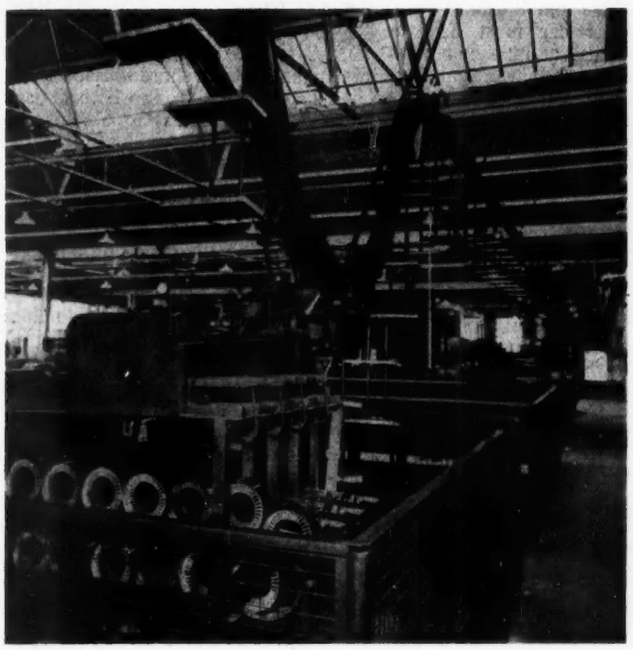


Fig. 3—After stove enamelling the stators are taken by an overhead conveyor to a store where they are automatically sorted according to size and discharged on to racks

The rotors follow a similar assembly line, starting with slotting of the rotor blanks, weighing of the laminations to obtain accurately the required rotor stacks, and alignment of the rotor slots. Then the rotor stack is mounted on a mandrel and placed in a casting press, where a single high-pressure stroke forces molten aluminium into the slots to form the squirrel-cage winding and the integral cooling fan. The surplus alloy is removed and the cylindrical surface of the rotor is turned to the finish diameter. After inspection at the end of the finishing line, the rotor is passed through a heat treatment furnace to relieve the squirrel-cage winding from the mechanical stresses associated with the casting process.

A tapered shaft is then pressed into the rotor and is ground to fit the journal bearings in the end shields of the completed motor. The rotor is then fitted with a centrifugal start-switch and is dynamically balanced and inspected before going into storage racks ready for the final assembly line.

In the meantime the motor end shields are produced in automatic, single-stroke, pressure die-casting machines. After automatic ejection from the die, each end shield is taken on an overhead conveyor to the fettling benches and then to the stove enamelling ovens (which are also traversed, separately, by the stators). Boring, turning, drilling and tapping, are done on the machining line, after which the end shields are inspected and checked dimensionally in readiness for the final assembly. Journal bearings, lubricators and oil seals are then fitted, the surface finish of the bearings being 3 micro-inches. A further inspection is followed by transfer to storage racks.

Complete sets of finished components are selected from the storage racks and placed on the final assembly conveyor. There they are built up into motors and then enter a testing tunnel which forms an extension of the assembly line. In this tunnel each motor is given an endurance test lasting about forty-five minutes, including fifteen start-stop cycles. During the traverse of the testing tunnel each motor takes its supply from overhead busbars. For final testing each motor is removed from the conveyor by an operator in an adjoining test booth (illustrated at top of page 614). Here readings are taken of no-load losses and the motor is fitted for load tests with a brake pulley ; with the help of a spring balance, full load and pull-out torques are applied. The motor is also flash tested and tested for silent running. Fittings such as covers and mountings are added and the motor is wrapped for despatch.

To complete this outline of a self-contained factory, some mention should be made of the facilities for engineering training provided at Newcastle by the company. In a separate block next to the main office building there is a specially equipped engineering training centre, where boys are trained as technicians, draughtsmen and craftsmen through five-year indentured apprenticeships. Training is planned from the start to take account of individual abilities and preferences. The early practical training given in the centre is based on the use of hand tools, machine tools and a variety of industrial processes, such as brazing, welding, heat treatment and sheet metal work. The weekly curriculum includes one "initiative period," during which each apprentice is allocated an unrehearsed job which must be completed without briefing or supervision. After the preliminary ground work, the boy leaves the centre to continue his apprenticeship on the factory floor, working with experienced craftsmen.

There is also a well-equipped training drawing-office in which drawing office, technician, and craft apprentices are given instruction in the company's draughting methods. Craft apprentices are thereby well-equipped to interpret working drawings in the shops, while drawing-office and technician apprentices are prepared for subsequent training in the engineering or planning drawing-offices, where they work on drawings directly concerned with the production of f.h.p. motors.

An apprentice's practical training in the works is backed by part-time study at the North Stafford Technical College, Stoke-on-Trent. A typical weekly time-table for the B.T.H. apprentice at Newcastle provides for one day at the Technical College. At present there are about fifty apprentices in the Newcastle works, but there is ample room for expansion. Some indication of the standard aimed at is given by the fact that, in 1956, one of the company's ex-apprentices won the first prize in the final examination in machine shop engineering of the City and Guilds of London Institute. As the prize-winner was also a student of the North Staffordshire Technical College, the college was awarded the Llewellyn Howel Memorial Trophy for 1956.

Low-Grade Materials for Road Construction

A PAPER describing the use of locally available materials, considered as "low grade," in road construction was read on April 3 before the Yorkshire and Lincolnshire branch of the Institution of Highway Engineers by Mr. F. W. Ingle, A.M.I.C.E., M.Inst.H.E.; it was entitled "Flexible Roads Recently Constructed Using Low-Grade Materials." As part of a general review of the economics of design of this kind, the author pointed out that apart from the cost of spreading different classes of material, it usually happened that only a single source of low-grade material was available of average C.B.R. value, and more often than not theoretically inadequate near the surface. Apart from any other consideration, therefore, such as waterproofing, the question of some sort of stabilisation for the top few inches immediately under the surfacing to improve the C.B.R. might then appear to be a reasonable and an economic proposition. In some cases that could have the effect of reducing the thickness of surfacing required. Geographical location and distance to be hauled generally determined the economics of the materials used. Low-grade materials were usually of a granular nature and particularly suitable for laying or processing with the maximum of mechanisation. Considering the case of a normal housing site of, say, 20,000 square yards, the road base could be stabilised with soil cement in a period as short as two to three weeks (for as much as 3500 square yards had been carried out in one day on carriageways where working conditions were exceptionally good), and a weekly average of 7000/10,000 square yards was quite reasonable. The placing of a low-grade granular base did not need to take a great deal longer, and the advantages of that speed of base construction were many.

Mr. Ingle continued by giving examples of recent construction with low-grade materials—soils stabilised with cement, stabilising imported materials with cement, cement stabilisation of unburnt colliery waste, and the use of burnt colliery shale in various ways, including stabilisation with bitumen and tar. Some work had been done using colliery shale with cement, but this more nearly approached a lean mix concrete. The use of chemically treated tar showed promise, and with this type of tar at low viscosity, which could be applied cold, it might be possible to develop a simple waterproofing medium to apply to the soil. Single sized or closely graded sands at the moment presented a problem when considering a medium for soil cement stabilisation. There appeared to be some promise of beach sands being suitable for stabilisation with certain types of cement for coastal protection, and there was always the problem of the possible water table, whether it could be lowered and what could be done to keep the formation stable and free from moisture changes and loss of strength. It was becoming increasingly difficult, the author pointed out, for him to pass a colliery heap, burnt or unburnt, or an overgrown sand pit, without wondering if there might not lie there some potential road-making medium which might be used with great advantage and economy.

Problems of the Small Utility Car

By D. GIACOSA*

THE James Clayton Lecture to the Institution of Mechanical Engineers was delivered last month by Dott.-Ing. D. Giacosa, on the subject of "Some Important Problems Concerning the Small Utility Car." We abstract below some of the lecturer's expressions of opinion.

On first thought the three-wheel arrangement seems to be rather attractive from the weight reduction standpoint as it appears to permit a remarkable mechanical simplification and a reduction in the number of component parts. However, a more thorough examination of the problem shows how these advantages are largely illusory and obtainable only if significant limitations of car quality are accepted. One of the several points of inferiority in the three-wheel motor car is fundamental: insufficient lateral stability. To have the same lateral overturning limit as a four-wheel car, a three-wheeled vehicle must necessarily have a wider track. This in turn implies an increase in frontal area and, therefore, maximum speed remaining unchanged, in greater engine power and increased weight of the entire structure. To form an idea of exactly by how much the track must be greater, it will suffice to point out that, assuming the vehicle weight to be equally distributed on the wheels, the track of a three-wheel motor car would have to be one and a half times the track of a four-wheel motor car having the same centre of gravity height. A contribution to increased vehicle dimensions is afforded also by the size of tyres which must evidently be larger than those equipping an equivalent four-wheel car. I do not think it worth while to analyse the different possible solutions: drive on the two-wheel axle and steering on one wheel, drive and steering both on the two-wheel axle, or drive and steering both on the single wheel. In any case, such a car will definitely be larger than the four-wheel counterpart and hence it cannot be lighter. Consequently, while vehicle cost cannot differ much, its running cost will most probably be greater on account of the increase in power required by reason of greater frontal area.

Viewing the location of the power plant in the light of the weight problem, it has to be decided which of the three following arrangements is better for a utility car: (1) front engine and rear axle drive; (2) front engine and front axle drive; (3) rear engine and rear axle drive. The vast and deep knowledge of all the problems associated with the different front and rear wheel drive systems, and the ample records of technical and experimental data gathered during years of production experience provide the necessary background to affirm unhesitatingly that, so far as vehicle functional characteristics and use are concerned, automotive engineering is at present in a condition to obtain practically the same results for any of the three solutions.

Operating on slippery roads and on snow, the small rear-engined car displays its in-born qualities at their best, as optimum road "bite" is added to good behaviour on curves. As may be easily imagined, owing to its peculiar weight distribution, the behaviour of this type of car on descents is far superior to the most exacting expectation.

The only serious objection that may be raised against the rear-mounted engine arrangement—in favour of the other two solutions, especially the "all forward" arrangement—is the impossibility of deriving from the standard saloon model the station wagon with rear door, the car that is called "giardinetta" in Italy, and has met with wide acceptance and success. However, the "all rear" arrangement offers the possibility of a solution which the other two are denied. Such a layout, which presents many advantages and particular attraction, is embodied in the type of car with steering ahead of front axle that in Italy is called "multipla."†

It must also be considered that the lower the maximum speed the longer the vehicle may happen to be used at the maximum output conditions compatible with traffic limitations. Therefore the engine and the other components of the slower car must be designed so as to permit use at maximum output for periods of time much longer than in the case of faster cars. It follows that their parts must be relatively sturdier. This in turn implies that the specific weight increment, as maximum design speed increases, will show a tendency to be lower.

However, it must also be considered that some categories of buyer are particularly reactive to purely exterior and showy refinements, and in view of this it will be necessary to make some concessions in weight for the addition of more or less elegant highly-polished parts.

Air-cooled and water-cooled engines giving the same power have substantially the same weight because to have the same life and reliability the air-cooled engine must have a larger piston displacement.

It is my opinion that under the present standard manufacturing technique no further reduction in bodywork weight is possible by reducing the sheet metal gauge or by resorting to other materials, such as light alloys or plastics. As to sheet metal thickness, practical reasons, such as the ability of withstanding bumps and the requirement of a sufficient stiffness against vibrations, bar a further reduction below present minimum figures, even in the case of parts for which strength is not the main requisite.

The following discussion will hold for curves negotiated with centrifugal force-to-weight ratios in the neighbourhood of 0·4 to 1, and for quick manœuvres as are carried out, for instance, when overtaking another car or avoiding a sudden obstacle. If the curve is entered and negotiated slowly these problems lose all significance. However, it would be wrong to think that, as the present traffic density at times imposes sudden steering, the problem is only important for sports cars; it is also remarkably important for the relatively slower cars. The behaviour of a car must be such as to provide the driver with the possibility of intervening with proper instinctive action to correct the vehicle direction; in other words, it is essential that car response to sudden steering reaction be adequate and neither abnormal nor excessive.

The conventional cars with non-independent rear wheels and with approximately equal load distribution on the two axles are not generally a source of particular difficulties in solving the problem, provided the designer does not ask for more than a sufficient stability, even if not perfect. In the case of these cars, once the requirements responsible for satisfactory "stability on curves" are met, "entering the curve" and "leaving the curve" will also usually take place correctly. In any case some minor design expedients will suffice to make the latter two features possible. Instead, with rear-engined cars having an all-independent wheel suspension, especially if production costs impose limitations in design selection, the problem becomes more complex and much more difficult to solve. Experience has shown that in small light cars of this type obtaining optimum stability on curves is possible while at the same time entering-the-curve performance can be unsafe and leaving-the-curve performance is annoyingly troublesome.

The defect of oversteering when entering a curve is inherent in small cars since, owing to the low value of their inertia moment with respect to the vertical axis, the response of these vehicles to a given control is more rapid than with large cars; that is, other conditions being identical, a small car enters the curve more sharply.

Extensive tests led us to the conclusion that in a small car with short wheelbase and a limited load on the front wheels it is a fundamental condition that to obtain consistent performance on entering the curve the orientation of steering wheels be unaffected by their vertical motion. When desired, however, the response of a car to controls in accordance with a particular law is obtainable by suitably operating on steering geometry; hence, to ensure entering the curve more gently the linkages may be so designed that the outer wheel tends to reduce the steering angle as roll angle increases.

The behaviour on leaving the curve depends greatly on how the car has behaved in the second stage of the curve. In any case, as pressure on the steering wheel is released, front wheels must right themselves and the car must resume a straight-ahead run with a spontaneous and not too violent movement. Also, it should always be avoided that after having reached their straight-ahead position, the steering wheels swing by inertia through an angle greater than strictly necessary, because in this instance the car might start to swerve in a direction opposite to that of the just-negotiated turn. Conditions may arise whereby this phenomenon occurs with such severity that if the car is not checked by the steering wheel it may take on a swinging movement that will dampen out only after some oscillations.

Power Plant Suspension: The excitation due to driving torque fluctuation, which originates a pitching motion, may be reduced to practically negligible values in a simple way. It suffices to render very flexible the train of components transmitting the drive from flywheel to wheels. To obtain this result on the "600," the shaft between clutch and gearbox has been rendered somewhat flexible and, furthermore, two rubber joints have been introduced on the rear wheel drive shafts. Thus only the secondary unbalanced inertia force and the flywheel inertia couple remain as exciting forces.

It is clear why it is impossible to design a good lower plant suspension where the layout is such that the engine axis is transversal to the car and, therefore, parallel to the output shaft. In this instance, in fact, the rigidity to rolling must be kept high in order to react, without excessive elongations, to the output torque and hence it would be impossible to avoid the resonances excited by the flywheel inertia couple within the engine operation range.

The Fiat 600 was born with a pressurised

* Director of Vehicles Engineering, S.p.A. Fiat, Torino, Italy.

† THE ENGINEER, April 27, 1956, page 416.

cooling system circuit in which at a pressure of 22·7 lb per square inch the corresponding maximum water temperature was 235 deg. Fah. Subsequently it was decided to bring the pressure down to a conventional 17 lb per square inch, corresponding to a maximum water temperature of 220 deg. Fah. This change was not prompted by technical requirements ; in fact, it seems that many motorists wish to be able to remove the radiator filler cap at any time, even when the engine is hot.

A problem of great interest I have not mentioned, but which deserves some consideration, is the suspension ; in a light car the ratio of sprung weight to unsprung weight is quite a drawback. For this reason, obtaining a satisfactory suspension design is much more difficult than would be the case with larger and heavier cars.

Manufacture of Plastics Patterns for Moulding

A COMPREHENSIVE investigation has been carried out over the past two years in the foundries at the Crewe Locomotive Works of the London Midland Region of British Railways into the use of plastics for foundry patterns. After initial difficulties and trials with various types of resins and fillers considerable success has now been achieved with patterns made with plastics, and several hundreds of the patterns are giving satisfactory service in the Crewe iron, steel and brass foundries. A report on these results has been prepared by Mr. H. G. C. King, the foreman of the Crewe pattern shop, and the following notes are based upon this report.

With the techniques developed, it is stated, patterns can be produced possessing considerable mechanical strength and with a surface finish at least equal to the best metal patterns, and at a cost of little more than the conventional wood pattern. After producing many thousands of moulds on a jolt squeeze machine the wear of this type of pattern has been found immeasurable. No elaborate plant or equipment is necessary and, for a small outlay, a start in the manufacture of plastics patterns can readily be made.

The main ingredients used for the plastics for making the patterns are stated to be " Epophen " epoxy resin, which is supplied liquid ; a filler which can be calcium carbonate or powdered slate ; and a hardening agent. A master pattern is required and as plastics patterns are formed by pouring a resin mixture into open moulds, usually made from plaster, split patterns of the type readily assembled on plates for machine moulding are particularly adaptable. The master pattern may be an existing pattern made for floor moulding, in which case it should be repaired and brought back to perfect condition before use. This can be done by normal repair or resurfacing with plaster is quite satisfactory, providing the finished master is well-coated with pattern enamel. The aim should be to have a master pattern dimensionally correct with a perfect surface, as any imperfections, even brush marks, will be reproduced on the plastics cast. Should it be necessary to manufacture a master pattern this can be of simple construction, as it will be strengthened by fixture to a board during use. The face of the pattern joint must be increased ¼in to provide material for subsequent machining. The prepared master pattern is then secured to a board and surrounded by a wooden frame leaving a minimum space of ½in between the pattern and frame, as shown in one of the illustrations. The sides of this frame must be ½in deeper than the highest point of the pattern.

A fairly thin mix of good grade plaster is poured into the frame and immediately it is firm the pattern can be withdrawn, the frame removed, and the mould thoroughly dried in an oven.

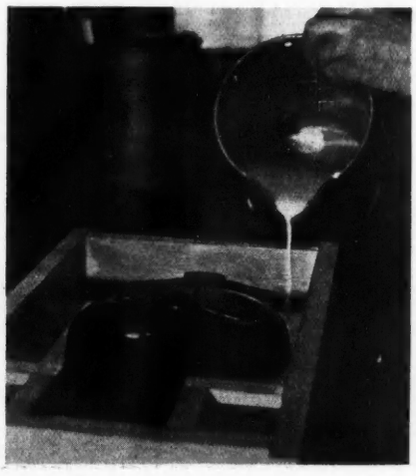
The surface of the mould which will come into contact with plastics is then sealed with a release agent in the form of a diluted wax polish or a lacquer.

For making the plastics moulds there are several formulas giving a range of casts from almost glass hardness to those of a flexible hard rubber consistency. The following mixture has been found particularly satisfactory : 100 parts by weight of " Epophen 841 " epoxy resin ; 75 parts calcium carbonate, and 15 parts of " 715 " hardener.

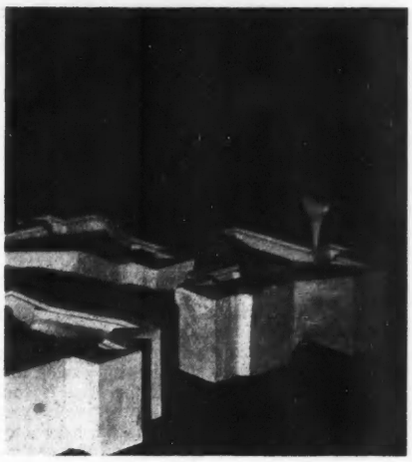
To estimate the quantities required for a particular cast the master pattern should be weighed, and if made of pine, it will be found that one-and-a-half times its weight will be sufficient resin ; therefore, if the pattern weight is 4 oz and four patterns are required, 1 lb 8 oz of resin should be poured into a " Pyrex " mixing vessel. To this is added 1 lb 2 oz of calcium carbonate. This substance or similar fillers counteract contraction and, using the above proportions, contraction will be negligible. Fillers also tend to increase mechanical strength and very much reduce cost. The hardener, 3 oz 9 drams, is then added and after thorough mixing the mixture is poured into the moulds slowly and with care to avoid trapping air pockets. The casts are left undisturbed in a temperature of 70 deg. Fah. for six to eight hours and then transferred to an oven, and the temperature increased to 180 deg. Fah. for four hours. Our second illustration shows prepared moulds being filled. When cooled to normal temperature, the moulds are stripped from the pattern with care as, until the material reaches full mechanical strength in about forty-eight hours, there is a tendency to brittleness. The patterns are finally machined to size on the top face and any surface imperfections reproduced from the master removed, before the whole surface is lightly polished with fine abrasive paper.

When it is required to make large patterns, material can be saved by making them of shell form. For these shell patterns a plaster core is introduced. The moulds are made in the usual way and lined with ¼in-⅜in thickness of plasticine and a mix of plaster poured to form a core. When firm this core is removed, the plasticine taken from the mould, and the core and the mould dried and treated with the release agent. Wooden strips to carry the core level with the mould face are secured with an adhesive, the core placed in position and the pattern cast made as before.

When required, plastics patterns can be reinforced by the introduction of fibreglass matting for large areas, or fibreglass rovings for more confined sections. In these cases pieces of matting and/or rovings, are cut to suitable sizes and thoroughly impregnated with the resin mix. As the mould is being filled the reinforcement is placed in position, building up in layers. It is advantageous to allow the resin mixture to stand from twenty to thirty minutes to thicken before pouring. This thicker mixture tends to hold the reinforcement in position. This technique can be applied particularly to the manufacture of core boxes. Small and medium core boxes will require a wall thickness of ¼in to 1in and with reinforcement will stand a reasonable amount of rapping. The smooth surface of such a core box reduces the need to rap to a minimum.



Master pattern in moulding frame which is being filled with plaster



Plaster moulds being filled with plastics compound

Repairs to these plastics patterns and core boxes is stated to be quite simple. In the case of breakage, the broken surface should be thoroughly cleaned and a normal resin mixture used as an adhesive. Should a part be broken and lost, the shape can be rebuilt by using a resin mixture which has been allowed to stand until thick enough to be applied with a palette knife. In all cases of repair heat treatment should follow and the rough built-up area can then be filed into shape.

The actual attachment of the patterns to plates is a relatively simple operation, the material being readily drilled and tapped for securing by normal methods.

It has been stated that plastics patterns can be produced at a cost of little more than wood patterns but, in accepting this slightly higher cost, the report points out that it should be appreciated that the superior surface of the plastics pattern is permanent and there is no movement of material, which can so often cause trouble during production when using wood patterns for machine moulding. Furthermore, the association of damp and warm sand does not affect their surface. When plastics patterns are compared with metal, a considerable saving both in manufacturing costs and time is shown. The production of a plastics pattern from a master is so good that, providing the master is correct, the finishing is confined to surface polishing, as distinct from the heavy cost of shaping and filing metal patterns.

GEAR CUTTING FILM.—We are informed by W. E. Sykes, Ltd., Staines, that it has produced a thirty-six frame film strip which is available on loan to lecturers at technical colleges and similar institutions, and work study groups. The strip is of a double-frame size on standard 35mm film, and is accompanied by a booklet of notes intended to assist in the preparation of a lecture on gear cutting. The strip provides illustrations of the Sykes plant, installations of gear cutting machines in the works of well-known engineering concerns, various types of gear shaper cutters and hobs, and illustrations and specification of all the firm's machines.

The portability of the open cycle gas turbine is illustrated by the arrival (left) of a Ruston "TA" engine at Carabobo, Venezuela. At cab roof height can be detected the floor of the turbine room: the ventilated space beneath is occupied by the exhaust ducts. Above the packing-case can be seen the extension housing the filters for air aspirated through the perforated bricks higher up. The four turbines are now installed (right)

Gas Turbine Power Station

THE C. A. Cemento Carabobo Sucra, Venezuela, commissioned last year in its cement works near Valencia a power station with four gas turbine alternators supplied by Ruston and Hornsby, Ltd. Operation of the kilns is continuous while the mills and other works are shut down for varying periods, and, hence, the use of a number of prime movers of less than 1000kW commended itself. Natural gas was available under pressure and was the natural choice of fuel, and dual-fuel compression-ignition engines were considered. Local labour and services are costly, however, and it was concluded that a gas turbine power station was the most economical proposition. The low noise level and absence of vibration were valuable near to a residential area.

The power house is a simple concrete building, and, in addition to housing the four alternator sets, provides space for a further two units to be installed when the peak power demand exceeds the maximum of 3600kW now available. The station is sited ¼ mile away from the cement works and upwind to avoid excess filter loading by cement dust.

One of the four turbines is a dual-fuel unit arranged to operate on either natural gas or distillate fuel oil in the event of an emergency failure of gas supply. In all other respects, the four sets are identical. Each comprises a standard Mark TA Ruston gas turbine of open-cycle design coupled to a Bruce Peebles revolving field, salient-pole alternator rated at 900kW, 2400V, three-phase, 60 cycles. The alternators are driven at 1800 r.p.m. through 3½ : 1 epicyclic gears, built to Allen-Stoekicht patents and forming an integral part of the turbines. Each alternator is mounted on a fabricated steel underbase, as is its associated turbine, and the whole unit is supported on a simple concrete foundation.

The stepped arches of the roof construction provide large openings which, together with the oil cooler fans which blow outwards, give a high rate of air changes and also considerable air motion, so that the highest temperature recorded in the power house is only 7 deg. Fah. (4 deg Cent) above that of the outside shade temperature. The exhaust gases are discharged through concrete chimneys and the ducting system is fully compensated for thermal dimension changes by means of expansion joints.

The switchgear was supplied by Erskine Heap and Co., Ltd., and includes a control panel and exciter cubicle for each set as well as two main 600A feeders. Merz-Price phase protection is provided and voltage control is by Brown Boveri rolling segment regulators. A swing-mounted synchronising panel has been installed and any of the four machines may be paralleled by remote governor-speeder control accommodated as press-button switches in the respective alternator panels. The main alternator circuit breakers have a capacity of 400A. A meter panel has also been installed with instruments to record total power production and individual kilowatts per hour per set. A station transformer of 50kVA capacity is fed from the main busbars and provides three-phase power for ancillary services, including the fans for the turbine lubricating oil radiators, and single-phase current for lighting. The main and auxiliary cables for this station were supplied by British Insulated Callender's Cables, Ltd.

The gas supply is regulated by Rockwell equipment from an incoming mains pressure of 270 lb per square inch down to 140 lb per square inch, at which it is distributed to the individual turbine control panels; the gas is dried by fluid separators. The natural gas, which has a net calorific value of approximately 900 B.Th.U. per cubic foot, is metered at each turbine.

A problem arose at an early stage of the contract when the cement company decided to purchase a new mill. This machine is driven by an auto-synchronous 1100 h.p. induction motor, which is required to start against a torque equivalent to approximately 1·5 times that at full load. A series of tests were conducted in the test shop at Lincoln in the presence of Cemento Carabobo's chief engineer, when a maximum non-inductive load of 900kW was thrown on to two machines running in parallel and sharing an existing load of 900kW. Although not entirely conclusive due to the nature of the test loads, these trials indicated that no undue difficulties need be anticipated in service. Subsequent experience has shown that, in fact, the actual requirements can be met by two machines without significant drop in voltage.

The total cost of this plant, including the building and installation charges, has worked out at £68 10s. per kilowatt. In spite of the ambient temperatures of about 80 deg. Fah., this figure is comparable with those claimed for larger gas turbine generating stations, and substantially lower than published prices for thermal power houses of up to 50MW.

The station is run by two operators per shift.

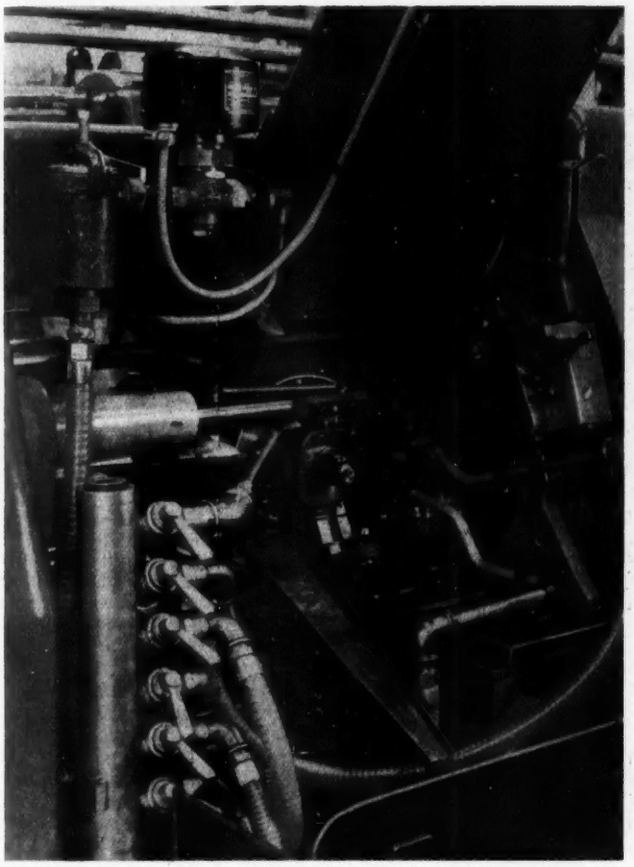
All-Weather Fighter

THE first English Electric P.1B. fighter made its first flight this month; it is one of three prototypes, which will be followed by twenty pre-production aircraft, which will be used for the development of the complex equipment needed for the execution of a supersonic interception.

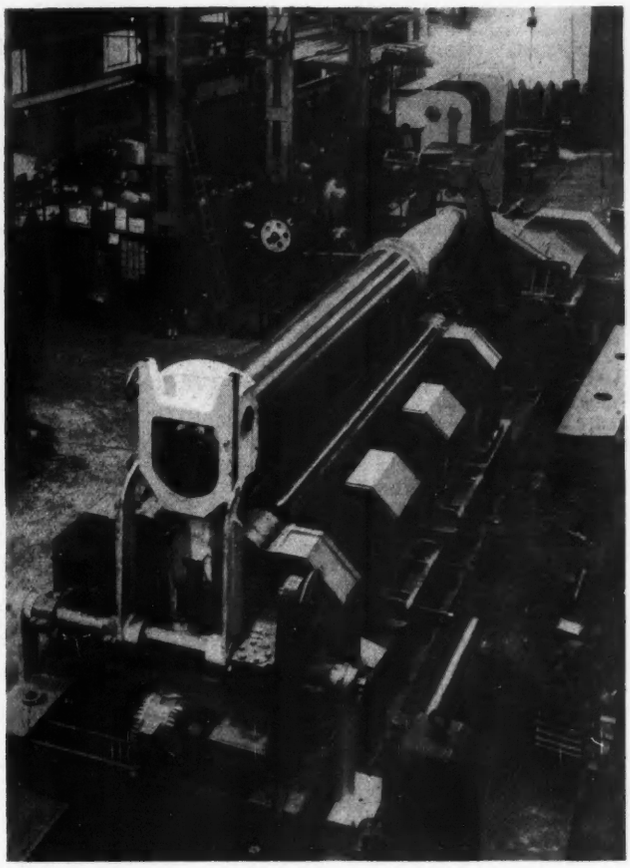
The illustration shows that the P.1B. resembles the P.1A., which is now described as a research aeroplane. There is now, however, a conical-shock supersonic intake in the nose: since the centre-body will obviously be required to accommodate a radar scanner, and the limited space available for fuel will render intake efficiency critical, it may be expected that the circular intake lip is adjustable for flight at various Mach numbers. For economical cruising one engine can be shut down; both are after-burning Rolls-Royce "Avon" single-spool jets. the latest variant of which, the R.A. 24, gives 11,250 lb thrust.

The aircraft will carry both guided missiles and 30mm Aden guns. The radar is described as "long range," and the plant providing cooling air to the cockpit and sensitive equipment is credited with 150 times the performance of a domestic refrigerator. Ministry of Supply and Royal Air Force test pilots will participate in the test programme, which is expected to occupy many months.

The English Electric "P.1B" has a dorsal spine from the canopy to the fin, and a more prominent canopy. This view shows that the wing is cambered near the root



The shrouded coil assembly at position 4 of automatic with the quenching fluid filter (left) and time switch valve (right) for controlling flow



Three-roll bending machine for plates up to 14ft long by 2in thick. An adjustment on the top roll end bearing provides for conical rolling

Induction Hardening Attachment on an Automatic

An interesting attachment for the local hardening of a component by induction heating and quenching during the machine cycle has been fitted to a six-spindle Acme-Gridley automatic supplied to Vauxhall Motors, Ltd., by B.S.A. Tools, Ltd., Birmingham. With the tooling set-up provided on the machine the component—a rocker adjusting screw—is completed in the one series of operations, which include burnishing, thread rolling and rear-end slotting.

The screw is made from accurately sized bar and the sequence of operations at the six stations of the machine are as follows :—

Position 6 : feed stock, turn stem diameter and rough radius.

Position 1 : form thread roll approach angle (60 deg. inc.), finish face radius end.

Position 2 : form and break down rear end, steady and burnish radius end.

Position 3 : form identification groove and thread roll on this position. The cams are timed so that the two operations are carried out consecutively, thus avoiding interference.

Position 4 : induction hardening.

Position 5 : (as illustrated) part off, pick up indexing pick-up attachment and rear end slot.

The high-frequency equipment used for the hardening process on the machine was supplied and installed by Wild-Barfield Electric Furnaces, Ltd., and consists of a standard 7·5kW A.H.F. generator. This unit is stationed adjacent to position 4 of the automatic with the h.f. leads being carried through a screened duct, which is itself firmly attached to the top member of the machine frame. The concentrator is carried by the same frame bracket.

The design of the concentrator nose is such that oil splash is prevented from falling on the tip of the screw during the hardening process. On indexing to position 4 the power is switched on automatically for a predetermined period, at the end of which time the component is quenched. For this quenching operation the cutting oil is used, and in order to prevent metallic swarf fouling the concentrator a magnetic filter is fitted in the line to clear the quenchant before it reaches the solenoid-operated quench valve.

The nozzle of the quench valve has been designed to ensure a sharp cut-off, and this enables a constant pattern to be obtained, as it gives a firm impingement of oil on the component at the beginning of the quench. The quenching medium is also used to cool the primary of the concentrator, and all quenching and cooling operations are fed from the cutting oil pipeline to position 4 of the machine. The general arrangement of the induction heating and the pick-up attachment for the milling of the screw slot can be seen in the photograph reproduced above (left).

Heavy-Duty Three-Roll Plate Bending Machine

One of the illustrations on this page shows a three-roll, heavy-duty, horizontal pyramid design plate bending rolls recently completed at the works of the Bronx Engineering Company, Ltd., Lye, near Stourbridge. It is designed to bend mild steel plate up to 14ft long by 2in thick to an inside diameter of 3ft 2in, or 1in plate to an inside diameter of 30in.

The top roll of forged carbon steel is 27in diameter and the two bottom rolls, which have grooves machined in their periphery to assist in gripping plates, are each 22in diameter. The bottom rolls work in phosphor-bronze lined bearings with hose caps in the heavy fabricated steel housings and the lower parts of these housings contain the worm gearing used for top roll adjustment purposes. The phosphor-bronze lined cast steel bearings of the top roll are pivoted to the upper ends of the adjusting screws. This arrangement allows the end bearing to be swung down for the removal of cylindrical work, and permits the roll to be operated in the tilted position for conical rolling. A 7½ h.p. motor is used for swinging down the end bearing.

Top roll adjustment is effected by a 60 h.p. reversible motor driving through reduction gears a main shaft coupling worm gearing in the housings. For roll tilting purposes a clutch in the main driving shaft can be disengaged. An indicator with a large dial at the operator's position shows the setting of both ends of the top roll. An extension over the top roll counterbalances its weight when the end bearing is swung down. This support extension engages the ball end of the roll and is operated by a 10 h.p. motor through a worm and screw gear. The roll housings are carried on a rigid fabricated steel bedplate, and securely bolted to one end of this bed is a base on which the gear drives, motors and controls are mounted.

The main drive for the rolls is by a 120 h.p., 960 r.p.m. reversible motor. This motor drives the main gearbox through a flexible coupling.

Institute of Marine Engineers.—On Tuesday, March 26, a paper entitled "Developments in Marine Electrical Installations with Particular Reference to A.C. Supply," was read by A. N. Savage, before the Institute of Marine Engineers. The paper endeavours to give the marine engineer a clearer understanding of the technical, operational and economic problems which have arisen as a result of the continually increasing size and capacity of electrical installations. The 220V d.c. system, particularly for the larger installations, is considered to be out of date, and it is suggested that a 440V, three-phase a.c. system, properly planned and carried out, will result in a safer and more reliable system which will be more economical in the use of raw materials. First cost will be less as will also maintenance charges. The paper traces d.c. development, discusses short circuit protection, and includes diagrams of three a.c. distribution systems which are described. Points concerning generating plant are examined and notes given on synchronising, switchboards, motors, control gear and lighting. Tabular statements are included which give the comparative cost of cables, and examples are given in which d.c. and a.c. motors are compared.

Industrial and Labour Notes

Overseas Trade

During the debate, last week in the House of Commons, on the Budget proposals, the President of the Board of Trade, Sir David Eccles, said that United Kingdom exports in March were valued at £297,000,000; imports were valued at £362,000,000, and re-exports at £16,000,000. The visible trade deficit was therefore £49,000,000. The March figure for exports, Sir David commented, was the highest ever recorded, and it afforded convincing proof of the underlying strength of our trade position. There had, of course, been distortions in the shipping position over the last few months, and the fairest period for comparison was the five months November to March. On that comparison, Sir David said, the monthly trade gap had been £47,000,000 in the current period against almost £60,000,000 a year ago.

Sir David went on to say that, according to information which had been coming into the Board of Trade, export orders in the last few weeks had been a good deal better than the Board's forecasts, and had been very well spread among different classes of goods. The demand for capital goods, Sir David continued, greatly exceeded the investment to meet it, and, in "physical terms," domestic investment in plant and machinery could not now be significantly increased without cutting into exports. It was true, he agreed, that there was now probably a little slack in the building industry, but not in plant and machinery owing to the increasing orders from overseas. It was very necessary, therefore, Sir David urged, that there should be enough movement in the economy to allow more capital goods to be produced.

Agricultural Machinery Exports

The annual general meeting of the Agricultural Engineers' Association was held in London on Thursday of last week, when Mr. Lionel Harper was re-elected president. Speaking at a luncheon which followed the meeting, Mr. Harper recalled that since 1938 the agricultural machinery industry had increased its exports by 500 per cent, and that three out of every five machines produced were now being exported. He went on to refer to the fact that in the last twelve months, with the co-operation of the Board of Trade, the industry had been successful in sending to China just over 300 tractors and 700 implements, to the value of more than £700,000. Agricultural machinery, Mr. Harper observed, with only those "token lots," was now Britain's fourth largest export to that market. For the China trade, however, this country was in keen competition with France, Germany, Italy, Czechoslovakia and Hungary.

Mr. Harper also spoke about the proposed European free trade area, in which, he said, there was a "big job to be done" by the agricultural machinery industry. The free trade area, he remarked, was one of the most rapidly expanding major markets of the world; in three years the Messina countries alone had increased their imports by more than 50 per cent and in 1955 they provided a market for about 20 per cent of the world's manufactured exports. In general, Mr. Harper continued, the British agricultural machinery industry's exports were almost double those of Germany, but to the Messina countries Germany's exports were twice as big as this country's. In tractor exports the two countries were about equal, Mr. Harper explained, but Germany was now sending four times as many tools for cultivating the soil and seven times as much harvesting equipment as we were to France, Belgium, Holland, Luxembourg and Italy.

Germany, Mr. Harper added, was able to deliver to all but Britain by road or rail without the necessity of crossing 20 miles or so of English Channel. Under present conditions, delivery from factories in Germany to the French border cost one-fifth of the carriage from our Midlands factories to Dunkirk. The Channel, Mr. Harper said, which had been a blessing in time of war, could be an obstacle to trade in time of peace. He would have felt a lot more confident of our ability to compete on the Continent, he commented, had he have read in the British Railways' modernisation plan "some encouraging reference to improving the means and cutting the costs of transport from our factories to our European customers." What a boon, Mr. Harper observed, the Channel tunnel would be for the future success of the British export drive on the Continent!

Anglo-Soviet Trade

The Russo-British Chamber of Commerce held its forty-first annual general meeting, in London, on April 11. The president, Sir Greville S. Maginness, said that there had been encouraging progress in the trade between this country and the Soviet Union, and expressed the view that there was undoubtedly considerable scope for a further expansion in both directions.

Sir Greville went on to say that, hitherto, the Soviet Union had always enjoyed a substantial favourable balance of trade with this country. Last year, however, there was a small unfavourable balance with the United Kingdom, as the value of our exports and re-exports at £55,900,000, slightly exceeded our imports from the U.S.S.R., which were valued at £55,100,000. The balance of trade did not, of course, entirely coincide with the balance of payments, as the latter involved time factors and invisible exports. It was interesting to note, Sir Greville continued, that in our last year's exports to Russia copper wire constituted the largest single item, the value being £15,000,000, compared with £8,600,000 in 1955. Next in order of value came machinery at £5,400,000, electrical machinery and apparatus at £2,400,000, and six trawlers valued at £1,900,000.

Federation of British Industries

On Wednesday of last week, the annual general meeting of the Federation of British Industries was held in London. Sir Hugh Beaver was elected president in succession to Sir Graham Hayman, who has held the office for the last two years.

Sir Graham presented the Federation's annual report, and in so doing reviewed the principal economic and industrial events of his term of presidential office. He said that whilst the Government's disinflationary policies had undoubtedly achieved a measure of success, the time had surely come for providing a new stimulus to productive investment and productive effort in order to regain the momentum which had been virtually halted during the past two years. A problem which caused renewed concern, Sir Graham continued, was that of productivity and related costs and prices. Last year, output per man fell by 2 per cent, but annual earnings per employee rose by 8 per cent, and material and fuel costs also rose. But, Sir Graham pointed out, in spite of those negative factors, the advance in the prices of manufactured products was only 4½ per cent, which indicated the extent to which industry exercised restraint in prices. This in turn, however, Sir Graham went on, necessitated a contraction in profits, which was of particular significance in view of the increasing need for industry to finance its own investment. The measure of that, he added, might be judged by the fact that in 1956 finance by undistributed profits amounted to £1500 million, as compared with £236 million by way of new borrowing.

At the end of his address, Sir Graham commented briefly on the Chancellor's Budget proposals. It was a relief, he said, to see that a first step had been taken to give to some of our key-men a somewhat more adequate reward for undertaking responsibilities, though nobody could be satisfied that the starting point for surtax should be left at a figure which had long since ceased to be an equitable basis of taxation, but had become a penalty on success. But it was regrettable, Sir Graham considered, that nothing had been done this year to encourage investment by the restoration of investment allowances. This surely overlooked the interval that must occur between the start of a new project and its implementation, and there had been signs recently that new schemes had been falling away. It was running some risk of delaying modernisation and expansion, Sir Graham said, if we had to wait another year before that stimulus was restored.

Iron and Steel

Britain's steel production during March averaged 431,000 tons a week, and was thus running at an annual output rate of 22,411,000 tons, compared with 22,141,000 tons a year earlier. But about 20,000 tons of steel output was lost in the last week of March on account of the strike of engineering workers which affected production in certain areas, particularly Lancashire and Sheffield. Pig iron production in March reached a record figure of 277,200 tons a week, the annual rate thus being 14,415,000 tons, compared with 13,624,000 tons last year.

The Iron and Steel Board has reported that finished steel deliveries from the United Kingdom mills in the first two months of this year totalled 2,878,700 tons, an increase of 3·8 per cent compared with the corresponding period last year. In the first two months of the year, the fall in the rate of deliveries to the motor vehicle industry and to the drop forging industry continued, although the decline was less marked in February than it was in January. On the other hand, steel supplies to the shipyards were 15·6 per cent higher in the first two months of this year than they were in 1956. The Iron and Steel Board says that deliveries to the shipyards in 1956 were 15 per cent greater than in 1955, and should help to increase this year's launchings. The shipbuilders and marine engineers have estimated that to enable their target to be attained the additional requirement of 150,000 tons of steel would have to be met by providing 75,000 to 100,000 tons extra this year and the balance early in 1958.

French Railways' Modernisation Plan

Electrification and increase in labour productivity are stressed in the French Railways' third "modernisation and equipment plan," which covers the years 1957–1961. *In the latter year freight traffic is expected to increase by* 30 *per cent over* 1954, *and passenger traffic by* 10 *per cent. This volume of traffic is to be handled without any increase in staff, or even with a slightly reduced staff. While the national output of power in terms of coal equivalent is estimated to rise to* 144 *million tons from the* 1955 *figure of* 112 *million tons, consumption by the S.N.C.F. will decrease from* 6·9 *to* 5·1 *million tons, or from* 6·2 *to* 3·5 *per cent of the total.*

A GENERAL Commissariat of the "Modernisation and Equipment Plan" was created in France on January 3, 1946. The aim of this governmental organisation was to study and co-ordinate the needs of the different sectors of French industrial activity and to present to the Government plans aimed at a balanced development of the national economy over a period of several years.

The first of these modernisation plans covered the immediate post-war period 1946–1950. In so far as the railways were concerned, it laid down a general policy, the technical details of which were drawn up by the S.N.C.F. : reorganisation and concentration of freight services, a policy of large marshalling yards and heavy trains, with corresponding tariff modification, and the development of electrification and diesel traction, particularly by means of autorails.

The second modernisation plan covered the period 1954–1957 (in actual fact the year 1957 has just been excluded to form the first year of a new plan). The modernisation programme of the S.N.C.F. included in this second plan followed the same lines as the preceding plan. However, the reconstruction of vital installations and the reconstitution of the network with a sufficient potential having already been achieved, the accent, in this second plan, was placed on an increase of productivity.

The completion of these two plans has completely transformed the French Railways : the policy of heavy trains—the average useful tonnage of a freight train increased by 70 per cent between 1945 and 1956—together with traction conversion, has allowed the number of steam locomotives to be reduced by almost one half ; numerous depots have been closed ; marshalling operations have been concentrated in some forty large, well-equipped marshalling yards, the others being reduced to a secondary role, or closed altogether ; 1900km of line have been electrified, among them the Paris-Lyons line and branches towards Geneva, the Savoy and Italy, and also the large group of lines situated around the Lille-Metz-Strasbourg line, on which traction with mains-frequency current has, for the first time, been used on a large scale.

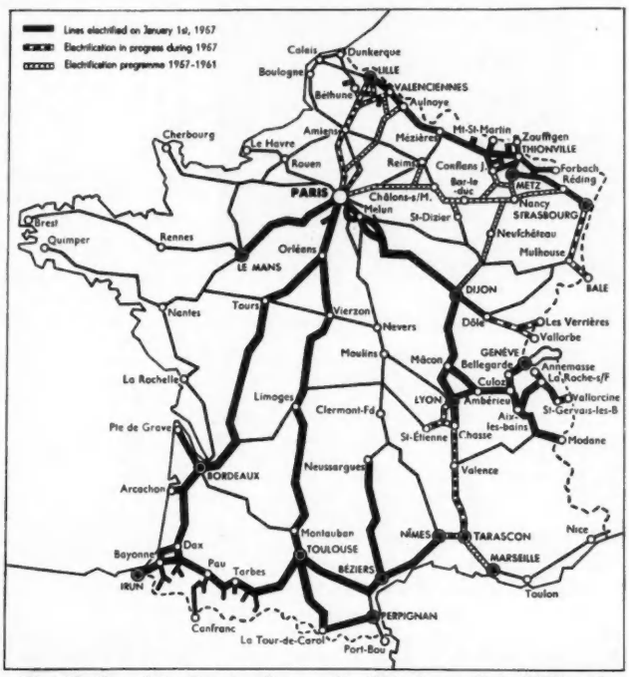
Results have been very remarkable: from 1946 to 1956, the productivity of the staff (traffic units per man-hour) has increased by 85 per cent, the productivity of power (traffic units per kilogramme of coal or equivalent) has increased by 55 per cent, the productivity of locomotives (ton-kilometres per steam or electric locomotive utilisable) has increased by 110 per cent. Thus, the S.N.C.F. can carry traffic which exceeds not only that of 1946 (by 15 per cent), but even that of the best pre-war year (1929), with less staff, a lower power consumption and with less rolling stock.

At the same time, the quality and safety of the service have improved : passenger trains running at a commercial speed in excess of 100km per hour were quite exceptional before 1939, and non-existent in 1946 by reason of the deplorable state of the network and rolling stock as a result of the war ; such journeys now total 47,000km every day. Regularity has also increased, both for freight and passenger services.

The third modernisation plan for the period 1957–1961 is at present being studied ; the principal objectives, in so far as the S.N.C.F. is concerned, are outlined in the following paragraph.

By comparison with 1954, there is to be, in 1961, an increase of 10 per cent for passenger traffic and 30 per cent for freight traffic ; progress should continue at the same rate after 1961. Productivity of the staff must be further improved. It is essential to carry the expected traffic without an increase of staff, because of the insufficiency of labour resources in the economy as a whole. Of particular importance is the improvement of the power balance, since the insufficiency of power resources has for several years been the principal bottleneck in economic development. Finally, transport costs are to be reduced. This objective is to be achieved as a direct consequence of the increased productivity.

Taking these requirements into account, the S.N.C.F. has prepared and submitted to the General Commissariat of the plan, a five-year programme for 1957–1961, which will now be briefly described.



Electrification of the French railways. By 1961, there will be 8000km of electrified lines, or 20 per cent of the whole S.N.C.F. system, which will carry 70 per cent of the total traffic

Adaptation of the Network to Traffic Requirements

Taking into account the traction conversion, the network will be able to deal quite easily with the expected increase in traffic. The principal work necessary concerns signalling. A further 600km of automatic block control will be installed including, in particular, the completion of the line Paris-Marseilles, as well as single line automatic block on the Dôle-Vallorbe line, which constitutes a new technical solution and a first step towards an "automatisation" of operation. Permanent way work will be carried out to improve the line at certain points or to create cross-overs or multiple tracks on lines with particularly heavy traffic, such as Paris-Tours, Dijon-Mâçon, sections of the Paris suburbs, &c. Lastly, several large modernised yards are to be extended and preparatory work is to be begun for the creation of two large new yards at Metz and Bordeaux. The yard at Avignon for fast traffic at present under construction, is to be completed.

Conversion of Traction

Electrification is again the principal item in the new five-year plan for the further modernisation and re-equipment of the French Railways (Fig. 1). This is not surprising, if it is remembered that the economies thus obtainable are not limited to the consumption of fuel but extend to train crews, maintenance staff and also to locomotive replacements, as an electrified line can be operated with less than half the number of engines required with steam traction.

The success of the new system of electrification using 25kV a.c. current at the industrial frequency of 50 c/s has convinced the French Railways that it should be adopted for all future electrification schemes, other than those of lines already mainly equipped for the use of 1500V d.c. To comply with the general directives for the new plan, the electrification for the five years 1957–1961 provides for a rate of progress 16 per cent higher than that achieved under the previous plan.

During 1957, electrification of the lines between Strasbourg and Bâle, Dôle and Vallorbe, and Frasne-Pontarlier will be completed. The Nord-Paris scheme, which includes the Paris-Lille line and various branch lines to Valenciennes and the principal coalfields, will be completed by the end of 1958. The conversion to electric traction on the 300 miles of line covered by this scheme will save 400,000 tons of coal per annum.

Extensions of the 1500V d.c. electrification south of Lyon to St. Etienne and Valence are also due for completion in 1958, with the sections Valence-Avignon and Avignon-Nîmes to follow in 1959 and 1960, respectively.

Further schemes of electrification covering over 900 miles of line with an estimated economy of 1,200,000 tons of coal per annum, are to be carried out. These comprise, commencing in 1957, the Paris-Châlons-Sarrebourg line with branches from Epernay to Reims, from Blesme to St. Dizier, from Lérouville and Nancy to Metz and from Toul to Neufchâteau and eventually Dijon ; and commencing in 1958, the lines between Creil and Aulnoye, and between Busigny and Somain, to provide the direct link between Paris and the Belgian frontier, and the mines at Aniche and Anzin. Finally, the scheme includes the suburban lines of the Eastern Region from Paris to Meaux, and of the Northern Region from Paris to Mitry and to Orry-la-Ville.

The five-year plan also provides for the extension from Tarascon to Marseilles of the electrification of the Paris-Lyons-Tarascon-Nîmes line.

When this programme is completed, the electrified lines on the French Railways will total nearly 5000 miles (approximately 20 per cent of the whole system). They will carry 70 per cent of the total traffic against 40 per cent as at present. The annual consumption of electricity for traction will then be 3500 million kilowatt-hours, a relatively modest figure when compared with the total consumption for all purposes in France, which will then probably exceed 75,000 million kilowatt-hours.

Diesel traction will also be developed : autorail services will reach their full extension and will include the new Trans-Europ-Express sets. Traction by diesel locomotives, which up to now has been mostly limited in France to shunting and

branch line services, will be extended to main line services, by the use of 1700 h.p. or 2000 h.p. locomotives, and, above all, of new single-engine locomotives of 1300 h.p. Steam traction will be completely superseded in certain areas, for example, the area south of the Loire and west of the electrified line Tours-Bordeaux.

Other Modernisation Plans

Modern signalboxes in several stations, for example, at Paris St. Lazare and Paris Austerlitz, will replace old boxes ; a great modernisation effort will be brought to bear on the telephone network and a teleprinter network will be created ; the programme also includes the elimination of level crossings or an improvement of their signalling, various works in workshops and depots (at Toulouse, for example), modernisation of passenger and freight stations, of tracks at the ports and of housing.

Not all the installations destroyed during the hostilities have yet been reconstructed : numerous bridges and buildings are still of a temporary nature. In particular, the reconstruction of those passenger stations considered less urgent, has had to be deferred until recent years for financial reasons. The S.N.C.F. hopes to be in a position to complete these works before 1961. Many of the destroyed installations will not, however, be rebuilt.

Power and Staff

The traffic expected for 1961 will be carried without an increase in staff—on the contrary, a certain reduction is anticipated—whereas, without modernisation, 15,000 to 20,000 more staff would be necessary.

The consumption of power, in coal equivalent, will be lower by about 3,000,000 tons than without modernisation. In fact, in spite of the traffic increase, the effective consumption of coal, which at present is 4,500,000 tons, will be reduced, in 1961, to 1,800,000 tons.

Table I—*French Power Consumption*
(in Millions of Tons of Coal equivalent)*

	1929	1938	1954	1955	1961†
Total French consumption	92	87	105	112	144
National production,	59	52	68	74	88
Power deficit	33	35	37	38	56
S.N.C.F. consumption	11·5	9·4	6·9	6·9	5·1
S.N.C.F. portion of total consumption, per cent	12·5	10·8	6·6	6·2	3·5

* The coal equivalent of the power consumed is calculated on the following basis :
1 kg fuel oil ... ... = 1·4 kg coal
1 kWh electricity ... = 0·6 kg coal
1 kg gas oil or petrol = 1·5 kg coal
† Estimate of third plan.

For many years the power balance of France has been in deficit, and it has been necessary to import coal, coke and oil. Table I gives an insight into this situation and brings out the part of the French Railways in the total consumption of power.

It will be seen, then, that the national power deficit has a tendency to increase, whilst the S.N.C.F. portion in the total consumption of power has diminished regularly. These tendencies should continue in the future, and the S.N.C.F. hopes by 1961 to have reduced the consumption of power to the equivalent of 5,100,000 tons of coal, which would not represent more than 3·5 per cent of the national consumption.

Large Mobile Transformer

A mobile transformer for 200,000kVA, 245kV, 3-phase, has been completed in the Stuttgart transformer works of A.E.G. Allgemeine Elektricitäts-Gesellschaft, for the Rheinisch-Westfalische Elektrizitätswerke A.G. This is the largest equipment of its kind which the firm has built. The accompanying illustration shows the transformer on its specially designed twenty-axle carriage, the total load of 200 tons being distributed over four bogies. In its windings are contained 72km of copper profiles of various sizes ; 40,000 litres of oil are employed for cooling.

Transformers of this size, it is stated, have to be sent by rail as road surfaces would not stand up to the pressures involved. On the railway, again, the loading gauge which must not be exceeded is given by the curves and bridge openings which have to be negotiated. The present transformer, therefore, is said to represent the largest capacity which can be carried by rail as a complete unit.

Infra-Red Dryer

We have received details of the "Hastra" Infra-red Motion Dryer, made by W. and Dr. K. Brechenmacher, Stuttgart-Wangen, Wasenstrasse 38, Germany. This equipment, which is shown in the accompanying illustration, is designed to speed up the drying of primers, surfacers, fillers, sizes and enamels with a nitrocellulose or synthetic base. It is stated that by reason of the short operating distance, the hot

Infra-red dryer for nitrocellular and synthetic paints

air blower which is attached, and the high density of radiation, a high degree of efficiency is attained. As an example, it is claimed that it takes less than an hour to paint a car mudguard, a job that includes priming, surfacing three times over, sizing and final camouflage coating. Air-drying synthetic resin enamels can be completely dried within a few minutes. The reflector has a diameter of about 13¾in. It is fitted with a 2·5kW element for 220V or 110V, and the total weight of the dryer is 4·4lb.

A Musical Instrument for Deaf-Mute Children

One of the numerous methods at present being employed for training deaf-mute children is to play music to them, and, more important still, to let them make music themselves. Although these children's hearing is greatly diminished, they are still capable of perceiving sounds above a certain threshold value, either through their ears or as vibrations felt by any part of the body, particularly the thorax. The main difficulty of teaching deaf-mute children to speak is to make them realise that these vibrations can contain information. It is therefore very important to train their sense of vibration. Another problem is the training of breath control. A wind instrument suitable for these purposes has been developed by the Philips Research Laboratories, Eindhoven, Netherlands.* It comprises a number of metal reeds, like a mouth organ, which are controlled from a keyboard. Piezo-electric microphones near the reeds pick up the sound, which, after amplification, is reproduced in the child's earphones. The screening of the microphones is sufficient to prevent acoustic feedback.

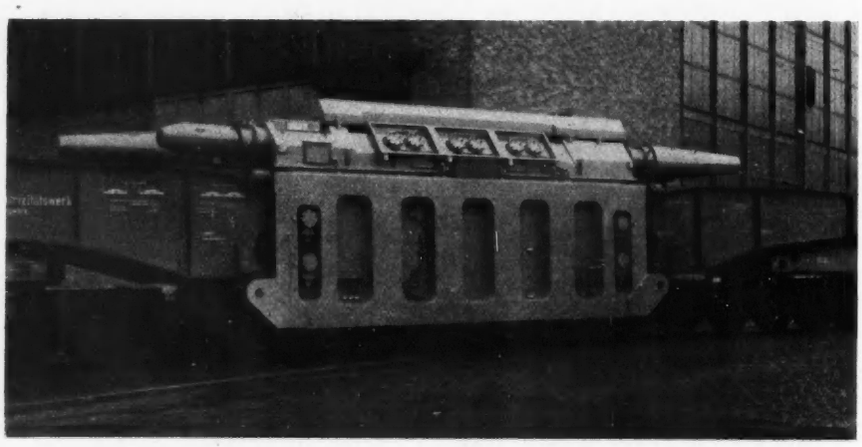
Mechanical Engineering Congress

It is announced that the Seventh International Mechanical Engineering Congress will be held at Scheveningen from June 2 to 6, 1958. It is being organised by the Vereniging van Metaal Industrieen, the Hague, on behalf of the Trade Associations of the Mechanical Engineering Industries of Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Italy, Luxemburg, the Netherlands, Norway, Spain, Sweden, and Switzerland. A main objective of the Congress will be the examination of matters currently influencing manufacturing progress both in the technical and economic spheres. The programme will include the presentation and discussion of papers, works visits, and certain group events. Working sessions will be conducted in English, French, or German, with simultaneous translations into these languages. Four-day study tours will take place at the conclusion of the Congress. A preliminary programme and registration forms are being prepared. Applications should be made to The British Engineers' Association, 32, Victoria Street, London, S.W.1.

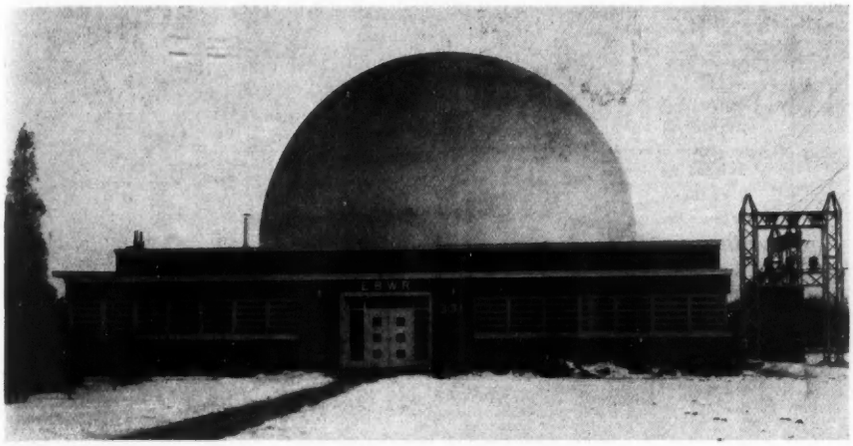
Abatement of Water Pollution

Some sixty experts from European countries, including the Soviet bloc, and from the United States, met from February 12 to 15, in order to discuss the problem of water pollution of lakes and rivers. An inventory of subjects for further study was drawn up, covering both the technical and the legal and administrative sides of the matter. Papers on various aspects of the problem, such as public health, industrial utilisation, fisheries and agriculture, had been prepared for the meeting by the secretariats of E.C.E., F.A.O., and W.H.O. The experts listed for further study such topics as pollution by hydro-carbons, phenols, detergents, and radio-active matter ; cellulose manufacture and organic synthetic chemistry ; comparison of national standards ; methods in use to reduce pollution and to purify waste water ; finance and organisation of installations for purifying water in international use. The proposals will be further considered at the opening of the twelfth session of E.C.E. in Geneva on April 30.

* *Philips Technical Review*, Vol. 18, 1956/57, No. 9, page 276



200MVA, 245kV, three-phase mobile transformer. The transformer weighs 200 tons



Experimental Boiling Water Reactor at the Argonne National Laboratory

BY OUR AMERICAN EDITOR

No. I

The experimental boiling water reactor (EBWR) at the Argonne National Laboratory, of Lemont, Illinois, was officially dedicated and went on the line in February, 1957. It is the first unit in the power reactor programme of the U.S. Atomic Energy Commission to be completed. The pile produces 20MW of heat, which, in turn, is used to generate 5MW of electricity for consumption at Lemont. The relatively small plant is mainly intended to study and to demonstrate the practicality of direct-cycle boiling water reactors for power generation. Initially, ordinary water is used in the reactor circuit, but it is planned to change over to heavy water in the future.

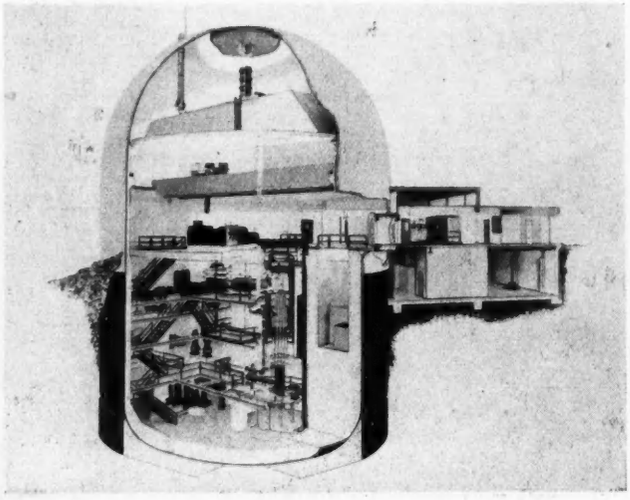
THE boiling water reactor was developed by the Argonne National Laboratory under the supervision of Dr. W. H. Zinn and the power station now completed at Lemont, Illinois, constitutes the first operating unit in the power reactor programme of the U.S. Atomic Energy Commission. In August, 1954, the Argonne National Laboratory engaged Sargent and Lundy, consulting engineers, of Chicago, Illinois, to prepare the engineering design for an experimental boiling water reactor installation with a rated electrical capacity of 5MW. Ground was broken in May, 1955, and the regular production of electric power commenced in February, 1957.

The EBWR plant has been built on the Argonne National Laboratory's site approximately 25 miles south-west of Chicago. Since this is a reactor which will be subject to many experiments, unusual provisions have been made to safeguard its operation. The reactor building consists of a steel cylinder 80ft in diameter and 119ft high, which contains the reactor, the turbine, the condenser and the auxiliary equipment. The shell has a volume of approximately 400,000 cubic feet and is designed for a maximum internal pressure of 15 lb per square inch gauge, so that in case an accidental rupture of the reactor shell should occur, all the radioactive vapour formed from the heat in the water in the reactor will be contained inside this shell. Normally, the operators will not be inside the shell as all operations can be directed from the control room. Access to the cylinder is through a large double door air lock with an emergency air lock that can also be used as a quick exit.

The part of the shell which is underground is backed up by a heavy inside concrete wall approximately 2ft thick, which braces the shell against the outside earth pressure. Originally, it had been contemplated not to have any concrete on the inside of the upper part of the shell, but in view of the experimental nature of the installation and in order to provide protection for possible missiles in case of turbine or other failure, a concrete layer approximately 1ft thick is provided on all sides as well as a suspended ceiling. The plant has a circular 20-ton crane for the handling of equipment. We illustrate the position of the reactor, turbine, condenser and other equipment as well as the large water-filled fuel storage well, where spent fuel is left for a period of time to reduce its radiation before it is taken away from the plant. There is a 15,000-gallon water storage tank situated on the top of the enclosure. This tank, in addition to supplying water for normal use, can also provide spray water in case of reactor failure and is open to the shell so that in case its pressure should increase, no additional head would be required for spray purposes. The plant is cooled by mechanical refrigeration in order to avoid using large amounts of outside air. One-half air exchange per hour is provided by a small fan and the exhaust air leaves the plant through a duct which is designed for a two-second hold-up time before the air leaves the top of the shell.

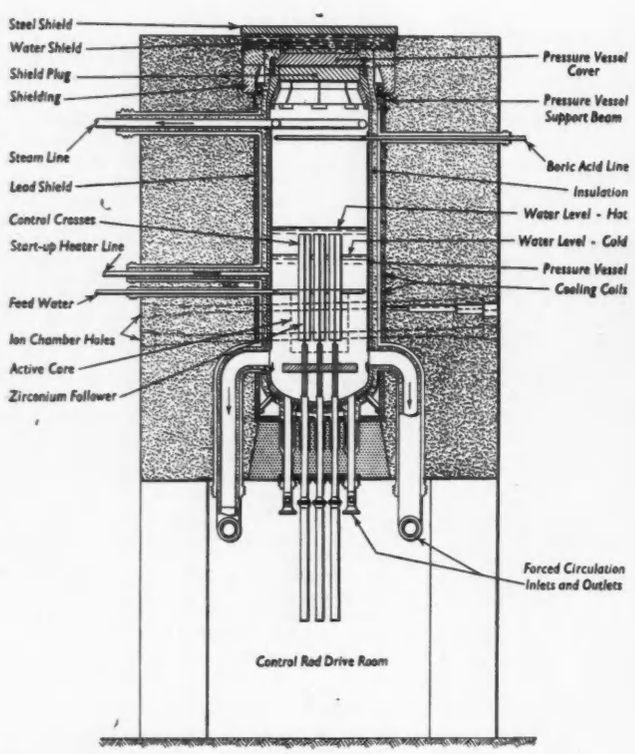
Reactor Principle

It is well known that in a power plant using nuclear fuels the reactor serves the same purpose as the boiler in a standard steam power station using conventional fuels. This is a very apt comparison in the case of the EBWR because the reactor is actually a boiler. Nuclear energy liberated by a chain reaction heats the uranium metal fuel plates. The heat is transferred to the water that comes in contact with the fuel plates. The water boils and part of it is converted to steam, which, at the proper pressure, is usable for generating electricity. In other designs of power reactors, a fluid, such as a gas, liquid metal, organic compound or water under very high pressure, is used to remove the heat from the reactor without boiling. The hot fluid is then used to generate steam in a heat exchanger. The direct steam cycle of the EBWR eliminates the need for the intermediate heat exchanger and permits the operation of the reactor at a pressure no higher than that required for the turbo-generator system. All designs of power reactors have their respective advantages ; the primary advantage of the boiling system is the simplicity of the reactor itself and associated power system. This offers the economy of construction



Artist's rendering of arrangement of EBWR nuclear power station

Carrier ring with index plugs at top of reactor vessel during refuelling



(Left) Sectional elevation of EBWR pressure vessel and core. (Right) Reactor core structure for fuel element support and control rod guidance being installed

and operation that accompanies simplicity.

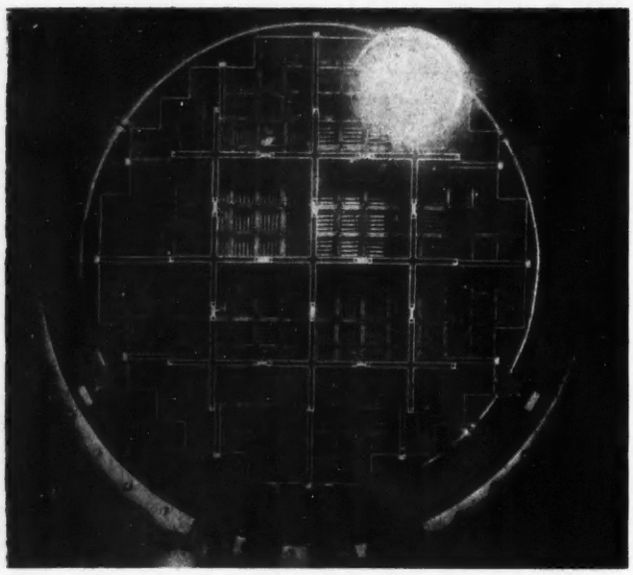
The EBWR is a thermal reactor, i.e. the neutrons produced by fission are slowed down by a moderator. This makes it possible to use uranium containing a low percentage of U-235 as fuel. The reactor fuel is a mixture of natural and slightly enriched uranium. Light water serves as both moderator and coolant. The reactor is cooled by the water as it boils and circulates through the core by natural convection. At a later date, forced circulation pumps may be used at Lemont to increase the power output and to study the effect of forced circulation on the reactor stability. The present reactor is an experimental one into which an unusual amount of flexibility has been incorporated. For example, the 4ft diameter core can be increased up to 5ft if desired. Fuel elements of different dimensions are provided to permit changing the water-to-uranium ratio in the core and studying the influence of steam void coefficient of reactivity on reactor stability. Two enrichments of uranium allow the critical size of and the power distribution pattern in the core to be varied. Although the reactor is designed for operation with a light water moderator and natural circulation cooling, the future conversion to forced circulation cooling will be relatively easy. If necessary, the entire core can be removed and replaced by one of radically different design. It is planned to substitute heavy water for light water and to install a core more suitable for a heavy water moderator after the desired operating experience is obtained with light water.

Reactor Pressure Vessel

The reactor proper is contained in a pressure vessel which is 7ft in diameter and 23ft high internally, and which has steel walls 2¾in thick. This vessel is mounted in a heavily shielded reactor well so that the top head of the reactor is just below the main ground floor level of the power plant building. The vessel is supported on its upper end by lugs resting on springs which, in turn, rest upon a steel frame attached to steel columns embedded in the concrete basement floor. The inner surfaces in contact with the reactor water or steam are clad with stainless steel. When the reactor is operating, the heat generated in the vessel wall by nuclear radiation will raise the temperature of the metal to 500 deg. Fah., which is above the saturation temperature of 489 deg. Fah. of steam at 600 lb per square inch gauge. The vessel wall is protected from excessive heat generation by a boron-stainless-steel thermal shield.

The reactor vessel was fabricated by the Babcock and Wilcox Company, of New York. The base material of the vessel is SA 212, Grade B firebox quality carbon steel, with spot-resistance welded stainless steel cladding. The internal piping, shock shields and all surfaces exposed to the primary water are of stainless steel. Designed to operate in a vertical position, the vessel provides for the functioning of the control rods through the lower head. Fusion-welded to the shell, the elliptically-shaped head contains nine control rod guide sleeves and nozzles, and four 6in diameter forced circulation system inlet nozzles. The core support rests on eight legs bolted to the bottom head ; the lugs attached here locate and support the thermal shield. Attachment lugs and a sealing ring are included in this head for the future installation of a pressure shroud when a forced circulation system is to be used. Access to the core elements is provided at the top of the vessel by a rotating plug and segmental shield arrangement, which provides a minimum of 9in of steel shielding. The top cover also has a double gasket seal with an annulus in between for purposes of leak detection and draw-off.

The vessel was designed in accordance with the A.S.M.E. Power Boiler Code, Section I, with special considerations for the structural problems caused by the nuclear application and the possibility of a transient power surge. Start-up, shut-down, or changes in the operating temperatures of this reactor induce thermal gradients through the vessel walls—and particularly through the head and the ring forging bolting flange—which result in thermal stress in addition to the normal steady state stress. Beyond the Code requirements for radiographic examination of all weld metal deposits, the nozzles were also radiographed. The vessel was hydrostatically tested to 1200 lb per square inch and subjected to a 1200 lb per square inch gauge helium test. The out-leakage of helium was determined by helium mass spectrometer capable of detecting a flow of 8×10^{-6} cubic centimetres of helium per second. The ring forging bolting flange was specially contoured to provide a



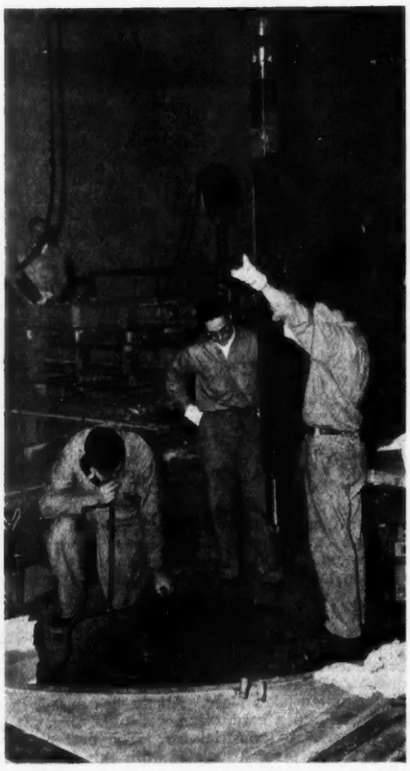
Loaded reactor with fuel element assemblies installed in reactor core

maximum efficiency of metal use, resulting in the thinnest possible cross-sections. This streamline contour with thin sections minimises the temperature differences which result from operating temperature changes. To ensure continuity of service without restricting the number of cyclic applications of the vessel, these transient stresses had to be limited to acceptable values. Radiation damage and high thermal stress in the vessel walls resulting from the high gamma radiation flux is held within acceptable limits by the use of a 1in thick shield of stainless steel of high boron content.

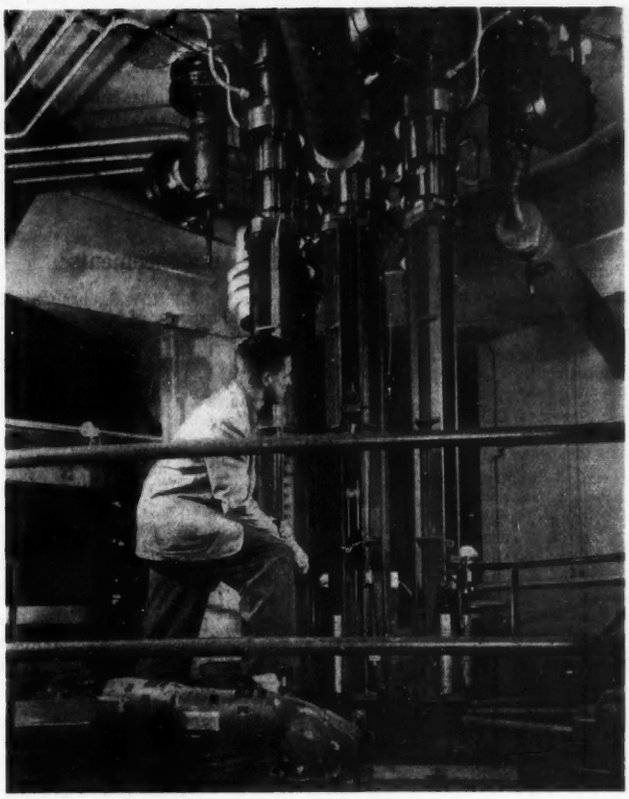
As can be seen from the illustrations, the top closure of the reactor consists of a bolted cover plate with double gasket seal, which provides a full opening for purposes of core maintenance or replacement. A shielding plug, with index plugs and removable insert plugs, is situated immediately below the closure. This assembly is stepped and sits on a ledge in the top ring flange forging, providing shielding when the top cover plate is removed for fuelling operations. For refuelling a carrier ring replaces the top cover plate (as illustrated on page 623) for additional shielding and operation of the lower shield plug. This ring has rotating, ball bearing-mounted index plugs which are turned by means of gears and pinions. The shielding index plugs are picked up by the carrier ring with bolts, allowing access to any area of the core through removal of the insert plugs after the shielding and index assembly is rotated to the desired position. The index plugs are stepped and a segmental shield ring provides complete shielding without open spaces. A minimum of 9in of steel at all points is thus provided.

Reactor Core

The reactor core within the pressure vessel consists of fuel assemblies and control rods fitted into a support and shroud structure that is bolted to the bottom of the vessel. The support plate and shroud structure will hold up to 148 fuel assemblies within a 5ft diameter. The present core, which is about 4ft in diameter, consists of 114 assemblies, of which 106 assemblies contain enriched (1·44 per cent U-235) uranium and eight contain normal uranium. There is a total of 6·1 short tons of uranium averaging 1·4 per cent U-235 in the core. Dummy assemblies are used to fill out the core to the 5ft diameter. The space between the core and the vessel wall is the downcomer space for the water as it circulates. The core shroud structure serves the triple purpose of holding the upper ends of the fuel assemblies, providing additional riser height above the assemblies to enhance natural circulation, and serving as the guide for the nine control rods moving within the core. The components in the active region of the core are made of Zircaloy-2, a metal which does not absorb neutrons readily and which has good corrosion resistance properties. The components outside the active region are fabricated from stainless steel. The loaded reactor is illustrated on page 624. The square fuel elements and the individual fuel plates within them may be seen. The nine cross-shaped control rod channels are shown, but the rods themselves are down inside. The light reflection comes from the surface of the water covering the assembly.



Individual fuel element assembly being loaded into the reactor core through upper shielding ring



Driving mechanism for the nine reactor control rods below the pressure vessel

Each fuel assembly is 77⅛in long by 3¾in square. An assembly is composed of a lower end fitting, six fuel plates, two side plates and a top fuel handling fitting. The lower end fittings are 3⅞in in diameter. Since the fittings are outside the active section of the core, they are machined from stainless steel rather than from the more expensive Zircaloy. Pilot fingers on the bottom guide the assembly into the support plate.

The fuel plates are uranium-zirconium-niobium alloy sheets manufactured in two thicknesses and two enrichments. One plate is 54in long, 3⅛in wide and 0·214in thick; the other is the same length and width, but is 0·279in thick. Both normal and 1·44 per cent enriched uranium are used in plates of both sizes. The uranium alloy is clad with Zircaloy-2 sheet by a hot rolling process. The nominal cladding thicknesses are 0·020in over the plate faces, 0·125in over the edges and 1½in over the ends. The six fuel plates are arranged parallel to one another with water channel space between adjacent plates. The side plates, measuring 61½in by 3¾in are made of Zircaloy-2 sheets. The top fuel handling fitting is made of stainless steel sheet formed into a box 3¾in square. Top ears furnished with holes provide lifting points, and flaps extending from the side of the box form springs which space the assemblies uniformly and provide lateral stability. The edges of the fuel plates are welded to the side plates by large plug-like spot welds spaced 3in apart along the entire length of the fuel plate. Three closely spaced welds are made at the ends of the fuel plate. Rivets are used to fasten the fittings to the side plates, since the two materials cannot be welded. The perforations in the side plates are designed so that the side plates will gradually creep to accommodate the increases in the lengths of fuel plates caused by irradiation.

The dummy fuel assemblies are made of aluminium-nickel alloy sheet $\frac{1}{16}$in thick. This alloy has exhibited promising corrosion resistance in laboratory tests and, for economic reasons, it is used in lieu of zirconium.

Nine control rods are used in the reactor. The control rods are made of neutron-absorbing metal. Fully inserted into the core, the absorber will prevent a chain reaction from occurring or stop one that is in progress. By pushing the absorber up and out of the active region the chain reaction can be started and the power level permitted to rise to the desired point. Two designs of control rods are used. Hafnium is the absorbing material in five of the rods, which are situated in the most effective positions. The other four rods are made from stainless steel containing 2 per cent boron.

The hafnium-Zircaloy-2 control rods are $\frac{1}{16}$in thick sheet metal bent into angles and spot welded together, forming cross-shaped sections 10in by 10in by ¼in thick. The end fittings are made of stainless steel. The upper 46in of the rod are hafnium, the middle 58in are Zircaloy-2, and the lower 71in are stainless steel. The rod weighs 97 lb. The boron rod has essentially the same dimensions, except that it is ¼in thick and weighs 141 lb. The sections of the rods below the absorber are made of Zircaloy-2, a metal which absorbs relatively few neutrons.

Although the control rods are installed and removed from the top, they are operated from the bottom through labyrinth seals on the lower ends of thimbles attached beneath the pressure vessel. During operation the absorber section of the rod is driven up out of the core followed by a Zircaloy-2 follower section which replaces the absorber in the guide channel. The release of the rods and rapid insertion for reactor shutdown takes place in less than one second. The rods are inserted by springs, gravity and the pressure in the reactor vessel. The springs serve to get the rods into motion quickly, they develop about 1000 lb of force and are effective for about 4in. An external dashpot decelerates the rod in the last 5in of travel. Under normal operations the drive power for the rods is furnished by a ½ h.p. electric gear motor. The unit is a reciprocating shaft machine with all operating parts outside the reactor vessel. Connection to the control rod is made with a chromium-plated extension rod passing through a pressure breakdown controlled leakage seal. All moving parts can be conveniently observed, serviced and replaced without draining the reactor.

(*To be continued*)

Personal and Business

Appointments

MR. BASIL Z. DE FERRANTI has been appointed a director of Ferranti, Ltd.

MR. S. J. L. SMITH has been appointed publicity manager of the United Steel Companies, Ltd.

MR. IVAN DORR has been appointed a director of Nu-Swift, Ltd., Elland, Yorkshire, in succession to Mr. G. W. Smith.

THE BRITISH TRANSPORT COMMISSION has announced the appointment of Mr. J. E. M. Roberts as director of training and education.

MR. A. MCNEILL has been appointed area sales engineer for Scotland of David Brown Industries, Ltd., industrial tractor division.

MR. E. M. GAMBLE has been appointed a director of Photo Printed Circuits, Ltd., Brookwood, Surrey, and of Camp Bird Industries, Ltd.

DR. ALFRED JAMES KENNEDY, A.M.I.E.E., has been appointed professor of materials and metallurgy at the College of Aeronautics, Cranfield.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION states that Mr. R. S. F. Edwards has been appointed general manager of London airports.

MR. J. DUMMELOW, A.M.I.E.E., has been appointed assistant manager, publicity department, of Metropolitan-Vickers Electrical Company, Ltd.

POWELL DUFFRYN TECHNICAL SERVICES, Ltd., has announced the appointment of Mr. J. T. B. Welbourn, M.I.Min.E., as chief coalmining engineer.

F. PERKINS, Ltd., has announced the appointment of Mr. Wilfred Ladds, A.M.I.P.E., as machine shop superintendent, in succession to Mr. G. Monro.

MR. LAURENCE GORMLEY has been elected chairman of the Metal Fixing Association (now known as the Metal Fixing Association for Building Insulation).

THE MINISTRY OF SUPPLY announces that Mr. H. Templeton has been appointed director of civil aircraft research and development, with effect from April 29.

THE MINISTRY OF SUPPLY AND THE WAR OFFICE announce that with the Queen's consent, Major-General J. G. Cowley has been appointed controller of munitions.

THE INSTITUTE OF BRITISH FOUNDRYMEN states that Dr. A. B. Everest has been elected president of the International Committee of Foundry Technical Associations.

THE BRITISH SHIPBUILDING RESEARCH ASSOCIATION has announced that Sir Charles Connell has been appointed chairman of the Council in succession to the late Mr. J. W. Elliott.

LONDON TRANSPORT, department of chief mechanical engineer (railways), has announced the appointment of Mr. R. I. D. Arthurton as assistant mechanical engineer (development), in succession to Mr. A. F. Collins, who has retired.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION, with the approval of the Prime Minister, has announced the appointment of Mr. P. Faulkner as a deputy secretary in succession to Sir George Stedman, who is retiring on May 31.

THE LONDON TRANSPORT EXECUTIVE has announced that Mr. H. R. Broadbent, traction engineer in the development division of the department of the chief mechanical engineer (railways), has been appointed principal executive assistant.

THE BRITISH TRANSPORT COMMISSION has announced that Mr. S. B. Bowskill has been appointed branch manager of Birmingham heavy haulage branch, Pickfords Division, British Road Services, in succession to Mr. E. Bulgin, who is to retire on May 20.

SCOTTS' SHIPBUILDING AND ENGINEERING COMPANY, Ltd., states that Mr. John Lee and Mr. John Finnie have been appointed directors. Mr. George Hilton has been appointed deputy managing director in addition to his present position of shipbuilding director.

MR. W. R. BLACK has been appointed managing director of the A.C.V. Group and, in consequence, has resigned his position as chairman of A.C.V. Sales, Ltd. He has also relinquished his post as managing director of Park Royal Vehicles, Ltd., but remains a director.

THE NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS, Bolbec Hall, Newcastle upon Tyne, announces the following appointments: Mr. Robert Cyril Thompson has been elected president and Mr. Allan James Marr and Mr. Christopher Stephenson vice-presidents.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION states that Sir Vincent Z. de Ferranti, M.I.E.E., has been elected president for the session 1957–58. Mr. J. O. Knowles, M.I.E.E., has been elected chairman of Council and Mr. W. Kenneth G. Allen, vice-chairman.

MR. ARTHUR WOOD has been appointed managing director of Henry Meadows, Ltd., in succession to Mr. Alister D. Mackay, who has been appointed to the main board of the parent company, Associated British Engineering, Ltd. Mr. Mackay remains as deputy chairman of Henry Meadows, Ltd.

MANN EGERTON AND CO., Ltd., has announced that Mr. R. W. B. Hawksley has been appointed managing director, and Mr. H. H. Chapman and Mr. E. W. Birkett, deputy managing directors. Mr. K. T. Boardman has resigned his appointment as deputy chairman and as an executive director, but remains on the board.

Business Announcements

MR. J. M. FURNIVAL, A.F.R.Ae.S., has retired from the post of general manager of Marconi Instruments, Ltd.

LLOYD'S REGISTER OF SHIPPING has announced that Sir Ronald Garrett has decided not to seek re-election as chairman of the society, a position he has held since July, 1946.

E. N. BRAY, Ltd., states that it has moved to a new factory its address being Control Gear Works, Britannia Road, Waltham Cross, Herts (telephone, Waltham Cross 2212–5).

MR. PETER B. GORST, export manager of Ransomes and Rapier, Ltd., is to leave England by air on May 2, for a sales tour of the Sudan, South Africa, Portuguese East Africa, the Rhodesias, Belgian Congo, Uganda and Kenya.

CRAWFORD COLLETS, Ltd., states that it has appointed Retselp Engineering, Ltd., Vulcan Road Industrial Site, Lode Lane, Solihull, Birmingham, as Midlands area stockists of its collets, collet chucks and feed fingers.

JOHN LAING AND SON (HOLDINGS), Ltd., and HOLLOWAY BROTHERS (LONDON), Ltd., have jointly announced that agreement has been reached in principle to the acquisition by Laings of a substantial interest in the Holloway Company and to its future operation in association with the Laing group.

CONCRETE, Ltd., Hounslow, Middlesex, states that its Scottish organisation has been formed into a separate company, Concrete (Scotland), Ltd. The board of directors is constituted as follows: Mr. G. Oyler, managing director; T. S. Lucas, K. M. Wood, J. M. Mitchell, J. Swale, F. A. Birtles and J. Wilson.

HEAT TRANSFER, Ltd., states that it has appointed W. B. P. Coleman, Ltd., 29, Oxford Street, Newcastle upon Tyne, as agent on the north-east coast, and McCulloch and Miller, 180, West Regent Street, Glasgow, C.2, as agent in Glasgow and its environs, for heat exchanger equipment and condensers.

THE CONTINUOUS CASTING COMPANY, Ltd., has announced its association with Davy and United Engineering Company, Ltd., and Newton Chambers and Co., Ltd. Sir Peter Roberts and Mr. K. E. Walker of Newton Chambers and Co., Ltd., and Mr. M. A. Fiennes and Mr. M. F. Dowding, of Davy and United Engineering Company, Ltd., have joined the board of the company.

Contracts

J. AND H. MCLAREN, Ltd., Leeds, has received an order from the Montreal factory of the Radio Corporation of America for diesel-electric equipment required to provide a continuous source of supply to radio apparatus for a wireless telegraphy scheme in the Province of Manitoba.

ACROW (ENGINEERS), Ltd., has received a contract valued at 200,000 dollars for travelling formwork to be used in Canada in the construction of the Beauharnois lock of the St. Lawrence Seaway project. The formwork assembly is claimed to be the largest of this kind yet made in the United Kingdom. It will accommodate 6000 tons of concrete, which will be placed continuously up to the maximum height of 85ft.

CROWLEY, RUSSELL AND CO., Ltd., Glasgow, has been awarded a contract amounting to £125,617 15s. 3d. for improving a length of just over half-a-mile of the Aberdeen-Inverness trunk road (A.96) at Sherriffmill, near Elgin. The works include the construction of a diversion of the trunk road for about a third of a mile and a new bridge across the River Lossie. The bridge will have a width of 36ft between parapets accommodating a 24ft carriageway and two 6ft footpaths. Messrs. Blyth and Blyth are the consulting engineers.

THE FREE PISTON ENGINE COMPANY, Ltd., Fallings Park, Wolverhampton, has received a contract from the Singapore City Council to supply free piston engines for an electric generating station in Singapore City. The contract, valued at over £1,500,000, is concerned with the replacement of the steam plant at St. James power station, and is for an installation giving a total output of 36MW, made up of six sets. Each set consists of eight GS.34 gasifiers of 1000 h.p. each, driving an exhaust gas turbine and direct-coupled alternator.

THE NATIONAL COAL BOARD OPENCAST EXECUTIVE has recently placed a contract with Sir Alfred McAlpine and Son, Ltd., Hooton, Cheshire, for the recovery of approximately 2,000,000 tons of coal from a site near Wrexham. The work is expected to last about six years and will involve the removal of some 25,000,000 cubic yards of overburden to depths up to 200ft. The contract includes the erection of a coal-handling plant which will have a capacity of 200 tons per hour. This plant is to be built by Sheppard and Sons, Ltd., Bridgend.

THE ENGLISH ELECTRIC COMPANY, Ltd., has received a contract from the Central Electricity Authority for four 105,000 h.p. water turbines, governors, storage pumps, and valves for the Ffestiniog pumped storage station in North Wales; it will be the first major pumped storage scheme in the United Kingdom. In the power station the storage pumps will be installed below the turbines and connected to them by disengageable couplings. The turbines will be rigidly coupled to the generator/motors. The 105,000 h.p. turbines will be the largest output water turbines of any type to be installed in the United Kingdom and will operate under a maximum head of 1050ft. Sulzer Bros. (London), Ltd., in association with Sulzer Bros., Ltd., Switzerland, are the sub-contractors for the storage pumps. All the English Electric work—and the larger pump components—will be done at Netherton Works (Liverpool), about 80 miles from the power station site. The station is due to start operation in August, 1961.

Miscellanea

COPPER DEVELOPMENT ASSOCIATION.—On Tuesday, April 9, Viscount Chandos formally opened the new offices of the Copper Development Association. These are at 55, South Audley Street, London, W.1, and include a display room in which exhibits demonstrate the properties and qualities of copper and its advantages for domestic applications, roofing, pipework and agriculture. Sir Ronald Prain is the chairman of both the council and management committee of the Association, which besides being available to provide technical information and practical advice, issues technical publications and has a number of films which may be obtained on loan.

CONTINUOUS SLAGGING BOILER FOR PADIHAM POWER STATION.—A 120MW reheat boiler is to be built at Padiham "B" power station (Burnley) by Simon-Carves, Ltd., for the North West, Merseyside and North Wales division of the Central Electricity Authority. It will be designed to generate 860,000 lb of steam per hour at 1600 lb per square inch and 1010 deg. Fah. with reheat of 785,000 lb per hour to 1005 deg. Fah. at the superheater outlet. The boiler will be fired by pulverised fuel in twin primary furnaces and will be continuous slagging to eliminate the handling and disposal of fine dust. In the continuous slagging system the dust collected from the boiler passes and dust extraction plant is recycled for slagging in the primary combustion chambers, from which it is continuously discharged together with the remainder of the ash which is slagged before escaping from the combustion zone; the discharged slag enters a water-filled trough, where disintegration takes place. All the fine dust is thus converted into a hard, clean, pellet-like slag, which can be put to industrial use. The dust electro-precipitation plant associated with this boiler will also be built by Simon-Carves, Ltd. It will have a guaranteed collection efficiency of 98·6 per cent.

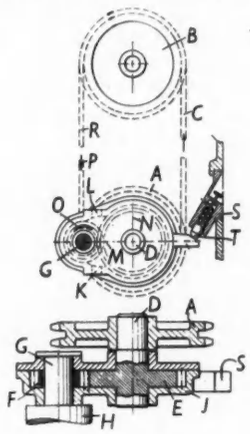
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

INTERNAL COMBUSTION ENGINES

770,826. June 14, 1955.—CHAIN DRIVES FOR CAMSHAFTS, Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany.

The invention relates to chain drives for the camshaft gearing for four-stroke internal combustion engines, and aims primarily at providing an arrangement which compensates for any elongation of the chain while changing as slightly as possible the previously adjusted timing. In the drawing the chain gear of the camshaft gearing comprises two sprocket wheels *A* and *B* of equal size, which are connected by chain *C*. The driving sprocket *A* is mounted on a journal *D* of a short shaft which is formed with a toothed gear wheel *E*, in mesh with a gear wheel *F* on one end *G* of the crankshaft *H* of a four-stroke internal combustion engine. The gear wheel *E* is twice as large as the gear wheel *F*, so that from the crankshaft *H* to the journal *D* there is a 2 : 1 reduction. As can be seen in the lower view, the short shaft of the gear wheel *E* is mounted in bearings in a lever *J*, which is rockably mounted on



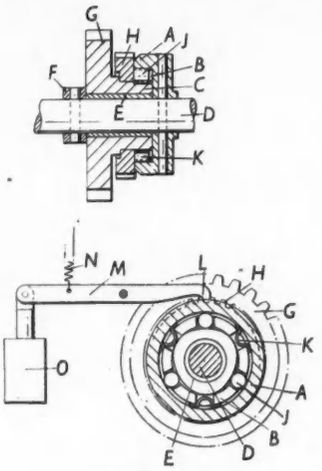
No. 770,826

the end *G* of the crankshaft *H* and is at the same time constructed as a housing for containing the gear train consisting of two gear wheels *E* and *F* and constituting together with the latter a gear pump. *K* and *L* are suction and delivery connections of this gear pump, which may be used for lubricating the engine. As can be seen from the upper view, the plane *M*, containing the axes of the driving sprocket *A* and the crankshaft *G* and the plane *N* containing the axes of the driving and driven sprockets *A* and *B*, are at right angles. In addition, the direction of driving (see arrow *O*) of the gear wheels *E* and *F* coincides at the point of mesh with the direction of movement (see arrow *P*) of the pulling side *R* of the chain, so that the tendency is to keep the chain taut. On the outer end of the lever *J* there is a projection, which tends to engage with a stop device *S* mounted on the crankcase of the engine. This stop prevents unintentional rotation of the lever *J* in the direction in which the chain *C* would be slackened. The stop device is resilient to assist in tensioning the chain and may comprise a spring-loaded plunger *T*.—*March* 27, 1957.

POWER TRANSMISSION

770,779. September 3, 1954.—CLUTCHES INCORPORATING WEDGING BALLS OR ROLLERS, Tiltman Langley, Ltd., formerly Tiltman Langley Laboratories, Ltd., Redhill Aerodrome, Redhill, Surrey. (*Inventor: Alexander Kenneth Clyde.*)

A clutch according to the invention has three concentric rotary components, namely, a driving member, a cage, and a driven member. In the clutch shown in the drawing the driving member *A* surrounds the cage *B*, which in turn surrounds the driven member *C*. The driving member is pinned to a shaft *D*. The driven member is lined by a bush *E* and can turn freely on the shaft, being held in place by a collar *F*. The driven member is integral with a pinion *G*, from which drive may be taken. The cage *B* is in the form of six fingers projecting axially from a toothed wheel *H*, which can turn on the driven member *C*. In alternate recesses between the fingers the cage houses three equally spaced rollers *J*. The driven member *C* is so shaped that each roller will become wedged in either direction from a central loose position. Thus the clutch will operate for both directions of rotation of the driving member. In the remaining recesses between the fingers the cage houses small resilient members *K*. These resilient members have the unstressed shape of a U with wings. When in position the wings are flattened and bear against the cylindrical surface of the driving member *A* so as to form the frictional



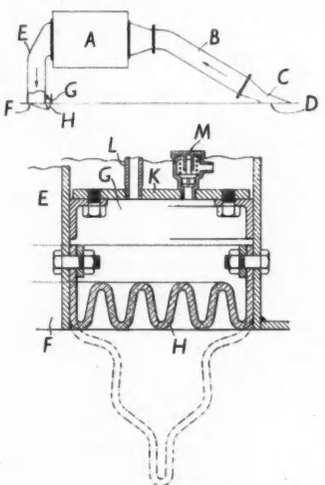
No. 770,779

drive. The brake is a dog *L* on the end of a rocking lever *M*. The brake is applied by a spring *N* and is released by energising a solenoid *O* to overcome the spring. In use the driving member is rotated and so long as the cage is held stationary by the brake the driven member also remains stationary in a position in which the balls or rollers are loose. As soon, however, as the brake is released the driving member begins to turn the cage through the friction drive, and the balls or rollers are carried into positions in which they become wedged in the tapering spaces and transmit drive. As soon as the brake is applied again the cage stops and the continuing rotation of the driving member loosens the balls. Thereupon the driven member stops.—*March* 27, 1957.

MARINE ENGINEERING

770,781. September 13, 1954.—SEA WATER COOLING SYSTEMS FOR STEAM CONDENSER UNITS, Yarrow and Co., Ltd., Scotstoun, Glasgow, W.4, and Andre Rubber Company, Ltd., Kingston Bypass, Surbiton, Surrey. (*Inventor: Eric Dott Hobson.*)

As shown in the upper view, a water cooling system of a condenser unit *A* includes a conduit *B* connected with a scooplike member *C* having an open end *D* on the outer surface of the ship's hull. On the outlet side of the system there is an outlet pipe *E*



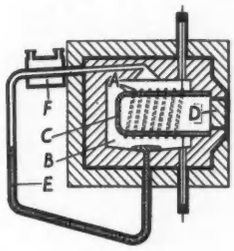
No. 770,781

having an open end *F* on the outer surface of the ship's hull. In operation when the ship is moving ahead sea water will be induced to flow in through the open end *D* and after circulating through the condenser unit will be discharged through the outlet pipe *E*. Adjacent to the open end *F* of the outlet pipe there is provided a recess or compartment *G* (see particularly the lower view). The open end of this compartment is sealed by a diaphragm *H* of rubber or like material, which is secured by clamping its edges to the opposed walls of the compartment. The inner wall *K* of the compartment is provided with an inlet *L* for supplying air or gas under pressure and a bore in which a suitable relief valve *M* is mounted. The compartment *G* extends across the forward part and along part of the opposed sides of the open end *F*. In the lower view the diaphragm *H* is shown in full lines in collapsed or inoperative position and it will be noted that it assumes a corrugated like condition across the open end of the compartment, the outer convolutions of the corrugations lying substantially flush with the open end. Accordingly no part of the diaphragm extends beyond the ship's hull to offer resistance. When the diaphragm is in this position the sea water circulating through the cooling system will be discharged through the open end *F* against the full back pressure of the sea water flowing past the open end. While the rate of flow of sea water through the system under these conditions may be adequate for normal cooling, if the temperature of the sea water is relatively high an increased rate of flow will be necessary. In this case gas or liquid under pressure is supplied to the compartment *G* through the inlet *L* and the increase in pressure will cause the diaphragm to flex out into the position shown in dot-dash lines and form a projection at the forward and side parts of the open end of the outlet pipe. This diverts sea water flowing past the ship's hull and creates a partial vacuum or area of reduced pressure in the region of the open end. The pressure against which the water circulating in the cooling system has to be discharged is accordingly reduced with the result that the rate of flow through the system will be increased. The diaphragm is shown by the dot-dash lines in its maximum expanded position. By regulating the pressure in the compartment *G* the diaphragm may be caused to project varying extents, thereby enabling the flow rate through the cooling system to be varied over a relatively wide range.—*March* 27, 1957.

ELECTRICAL ENGINEERING

770,402. October 8, 1953.—ELECTRIC FURNACE, Siemens and Halske Gesellschaft m.b.H., Apostelgasse 12, Vienna III., Austria.

According to the invention, a muffle used in the furnace for containing the material to be heated, is adapted to maintain the material out of contact with the atmosphere and is heated by a coil made of a material susceptible to oxidation. The furnace space contains a moving atmosphere of mercury vapour which is continuously passing over the heating coil



No. 770,402

to prevent oxidation. A particular advantage of the furnace is that it permits a separation of the space containing the substance to be heated from the space containing the heating coil and the protective gas (i.e. the mercury vapour) and serves to prevent the undesired diffusion of the protective gas into the space containing the substance being heated. As shown in the drawing, the furnace comprises a heating coil *A* made of tungsten or molybdenum which are susceptible to oxidation. A furnace space *B*, which has a highly refractory walling and is gas-tightly sealed, accommodates a muffle *C*, which is heated from the outside; *D* is the seal of the muffle. The heating coil *A* is continuously swept by a stream of mercury vapour which is circulated through a closed circuit, one portion of which comprises the furnace space *B* and another portion of which comprises a conduit *E* outside the furnace. Thus, the conduit extends between an outlet arranged at the apex of a conical or funnel-shaped depression in the furnace wall at the top of the furnace space *B* which surrounds the heating coil *A*, through the condenser *F*, where the vapour is cooled, and to the bottom of the furnace space. The mercury is evaporated from the pool in the bottom of the furnace space under the action of the heating coil itself. If desired, an additional mercury evaporator may be provided whereby liquid mercury may be evaporated before the heating coil is heated and thus any initial oxidation of the heating coil may be prevented.—*March* 20, 1957.

Launches and Trial Trips

H.M.C.S. BONAVENTURE, light fleet carrier ; built at Belfast by Harland and Wolff, Ltd., for the Royal Canadian Navy ; length 700ft, beam 80ft (excluding sponsons), displacement 19,900 tons, speed 24 knots ; complement 1200, tracker anti-submarine aircraft and Banshee all-weather jet fighters, helicopters, eight 3in, 50-calibre anti-aircraft guns in four mountings ; two sets of steam turbines. Commissioned January 17.

FIRBANK, open shelter deck cargo liner ; built by William Doxford and Sons (Shipbuilders), Ltd., for the Bank Line, Ltd.; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded 29ft 6in, deadweight 10,410 tons ; five holds, one 25-ton, four 10-ton and ten 5-ton derricks, electric winches ; Doxford opposed-piston oil engine, four cylinders, 700mm diameter by 2320mm combined stroke, 4800 service b.h.p. Trial, January 28.

DAVID WOOD, trawler ; built by John Lewis and Sons, Ltd., for the Minerva Fishing Company, Ltd.; length overall 133ft, breadth 25ft 6in, depth moulded 12ft 9in, gross tonnage 300 ; fish room 6500 cubic feet, 150 b.h.p. electric trawl winch, barrel capacity 800 fathoms 2¼in warp, one 125kW diesel-driven winch generator, two 20kW diesel-driven generators ; one Widdop mark G.M.B.7 diesel engine, 640 b.h.p. at 250 r.p.m. Launch, January 14.

RONA, cargo ship ; built by Hall, Russell and Co., Ltd., for the Colonial Sugar Refining Company, Ltd.; length between perpendiculars 365ft, breadth moulded 54ft 6in, depth moulded 34ft 9in, deadweight 6600 tons on 23ft 6in draught ; eight passengers ; four holds, one 25-ton, one 15-ton and twelve 5-ton derricks, electric deck machinery; three 180kW diesel-driven generators ; Ailsa-Doxford four-cylinder oil engine, 3000 b.h.p. Launch, January 15.

RISELEY, cargo ship ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd.; length between perpendiculars 440ft, breadth moulded 61ft, depth moulded to shelter deck 39ft 1in, deadweight 11,000 tons on 26ft 3in mean draught ; five cargo holds, ten 3-ton derricks, steam winches ; two 45kW steam-driven generators ; Swan, Hunter-Doxford oil engine, four cylinders 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m. Trial, January 4.

AEGEAN ISLAND, cargo ship ; built by the Burntisland Shipbuilding Company, Ltd., for Aquila Compania Naviera S.A., Panama ; length between perpendiculars 435ft, breadth 59ft 9½in, depth to upper deck 39ft 6in, draught 29ft 3in, deadweight 11,800 tons ; five main holds, one 30-ton, six 10-ton and four 5-ton derricks, electric deck machinery ; three 200kW diesel-driven generators, one 40kW emergency generator ; Kincaid-B. and W. two-cycle, single-acting, diesel engine, seven cylinders, 620mm diameter by 1870mm combined stroke, 5500 b.h.p. at 120 r.p.m., heavy fuel. Launch, January 17.

TRINCULO, ore carrier ; built at the Wallsend yard of Swan, Hunter and Wigham Richardson, Ltd., for the Bowring Steamship Company, Ltd.; length between perpendiculars 480ft, breadth moulded 69ft, depth moulded to upper deck 38ft 3in, mean summer draught 27ft 6in, deadweight 14,500 tons, service speed 13½ knots ; four ore holds, fitted with single-pull MacGregor hatch covers, pump room amidships, steam winches ; two multi-tubular Scotch boilers, Wallsend-Doxford oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4350 b.h.p. at 115 r.p.m. Launch, January 30.

NAESS COMMANDER, oil tanker ; built by the Netherlands Dock and Shipbuilding Company for the Nederlandse Norness Scheepvaart Maatschappij, Amsterdam ; length overall 700ft, breadth 93ft 6in, draught 36ft 2¾in., deadweight 39,000 tons, trial speed 17 knots ; four 1250 tons per hour turbine-driven centrifugal pumps and three 150 tons per hour stripping pumps ; two 550kW, 450V, 60 cycles alternators and one 120kW diesel-driven alternator ; one set of Parsons two-cylinder, double-reduction geared turbines, 15,000 s.h.p. at 98 propeller r.p.m. or 16,500 maximum s.h.p. at 101 propeller r.p.m.; steam supplied at 600 lb per square inch and 800 deg. Fah. by two Babcock and Wilcox boilers. Launch, December 21.

Catalogues and Brochures

DANITE HARD METALS, Ltd., Danite Works, Carr Hill, Doncaster.—Leaflet describing "Diard" grinding wheel dressers.

OZONAIR ENGINEERING COMPANY, Ltd., The Esplanade, Rochester, Kent.—Publication describing a continuous cleaning "Ventex" air filter.

ACHESON COLLOIDS, Ltd., 18, Pall Mall, London, S.W.1.—Illustrated folder summarising the properties and characteristics of "DAG" colloidal graphite.

VENNER ELECTRONICS, Ltd., Kingston By-Pass, New Malden, Surrey.—Publication No. VE 104, giving details of a range of transistorised plug-in stages.

THE BELMOS COMPANY, Ltd., Bellshill, Lanarkshire.—Leaflets No. K450, giving details of four and five-tier direct switching starters, and No. 1295, describing an air-break automatic "Star/Delta" starter.

HILGER AND WATTS, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1.—Folder describing the "Fluorite Polychromator," an instrument for analysing carbon, phosphorus and sulphur in steel.

WILKINSON RUBBER LINATEX, Ltd., Camberley, Surrey.—Leaflet No. 115/0157, describing the Mark 2 Linatex valve, a full bore, straight through, abrasion and corrosion-resisting flanged type valve.

QUASI-ARC, Ltd., Bilston, Staffordshire.—Technical circular dealing with manipulative equipment for manual and automatic arc welding. Details of roller beds, cantilevers and radial beam positioners are included.

METALECTRIC FURNACES, Ltd., Cornwall Road, Smethwick, 40, Staffs.—Leaflets Nos. M25 and M26, dealing with mains frequency non-ferrous melting furnaces, types 1–2 and 3, and types K150, K200 and K300.

BIRFIELD INDUSTRIES, Ltd., Stratford House, Stratford Place, London, W.1. Illustrated folder describing the "Flowmetric" valve, designed for applications requiring not less than ¾ g.p.m. or more than 5 g.p.m. of water.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Wed., April 24.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, "Practical Applications of Modern Science," H. E. J. Butler, 7.30 p.m.
Thurs., April 25.—KENT BRANCH : County Hotel, Canterbury, "The History of Lighting," J. Roper, 8 p.m.
Sat., April 27.—OXFORD, READING AND DISTRICTS BRANCH : Collier Lecture Room, Regents Park College, Pusey Street, Oxford, "Applications of the Cathode-Ray Tube," C. H. Gardner, 6.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Thurs., April 25.—Management House, 8, Hill Street, London, W.1, "The Appointment of an Employee Director," E. O. Landau, 6.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., April 24.—LONDON SECTION : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "The Properties of Semiconductor Devices," A. A. Shepherd, 6.30 p.m.
Fri., April 26.—SCOTTISH SECTION : Department of Natural Philosophy, University of Edinburgh, Annual General Meeting, followed by "Special Process Instrumentation in Atomic Energy Projects," H. Bisby, 6.30 p.m.

COMBUSTION ENGINEERING SOCIETY

Wed., April 24.—LONDON SECTION : Waldorf Hotel, Aldwych, London, W.C.2, "The Selection of Plant for Power and Process Requirements," R. Nichol, 10.30 a.m.

ENGINEERS GUILD

Mon., April 29.—EDINBURGH CENTRE : Scottish Liberal Club, Prince's Street, Edinburgh, Annual General Meeting, 6.15 p.m. ★S.W. ESSEX CENTRE : Dr. Johnson Hotel, Barkingside, "Rural Preservation," J. A. Fisher, 8 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, April 19.—LIVERPOOL CENTRE : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Modelling with Light and Colour," A. Wilcock, 6 p.m.
Fri., April 26.—BATH AND BRISTOL CENTRE : S.W. Electricity Board, Bath, Annual General Meeting, 7 p.m. ★ BIRMINGHAM CENTRE : Regent House, St. Phillip's Place, Colmore Row, Birmingham, "A Feminine View Point on Domestic Lighting," Mrs. Kay Hudson, 6 p.m.

INCORPORATED PLANT ENGINEERS

Thurs., April 25.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, "Welding Applied to Maintenance," A. O'Donnell, 7.30 p.m.
Fri., April 26.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Earthing and Earth Leakage Protection," J. A. Robbins, 7.30 p.m.
Mon., April 29.—WEST AND EAST YORKSHIRE BRANCH : Leeds University, Films, "Basic Principles of Lubrication," and "Let go For'ard," 7.30 p.m. ★ Cromwell Hall, Earls Court Exhibition Building, London, S.W.5, "An Engineer Looks Ahead—Modern Trends in Factory Design and Equipment," E. C. Stevens, 2 p.m.

INSTITUTE OF FUEL

Wed., April 24.—LONDON SECTION : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Presidential Address, J. R. Rylands, 7 p.m.
Thurs., April 25.—LONDON SECTION : Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2, Annual General Meeting and Luncheon, 12.30 p.m. ★ E. MIDLAND SECTION : Gas Showrooms Lecture Theatre, Nottingham, Annual General Meeting, followed by "Nuclear Power," F. M. Greenlees, 6.15 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., April 29.—W. OF ENGLAND SECTION : Grand Hotel, Bristol, Films, "The Back of Beyond," "Rig 20," and "We've Come a Long Way," 7.30 p.m.
Tues., April 30.—85, Minories, London, E.C.3, Annual General Meeting, 5.30 p.m.

INSTITUTE OF METALS

Mon. to Fri., April 29 to May 3.—JOINT SPRING MEETING : Monday to Wednesday, Church House, Great Smith Street, Westminster, London, S.W.1 ; Thursday, 17, Belgrave Square, Westminster, London, S.W.1, followed by visits.

INSTITUTE OF NAVIGATION

Fri., April 26.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Methods of Obtaining a Ship's Aspect and Speed by Radar," R. G. Swallow and A. L. P. Milwright, 5.15 p.m.

INSTITUTE OF PHYSICS

Thurs., April 25.—MIDLAND BRANCH : Regent House, Birmingham, "The Strength of Metals," A. H. Cottrell, 7 p.m.
Fri., April 26.—S. WALES BRANCH : University College of Wales, Aberystwyth, "Instrumentation of the Liverpool Synchrocyclotron," B. Collings, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., April 23.—E. REGIONAL CENTRE : Houldsworth Hall, 90, Deansgate, Manchester, Annual General Meeting, 7.30 p.m.
Tues., April 30.—E. MIDLANDS CENTRE : Mechanics' Institute, Nottingham, Annual General Meeting, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Fri., April 26.—GRADUATES' AND STUDENTS' SECTION : Cora Hotel, Upper Woburn Place, London, W.C.1, a Symposium on "The Impact of Atomic Energy on Chemical Engineering," 9.45 a.m.
Sat., April 27.—GRADUATES' AND STUDENTS' SECTION : 16, Belgrave Square, London, S.W.1, Annual General Meeting, 10.30 a.m.
Tues., April 30.—May Fair Hotel, Berkeley Street, London, W.1, Thirty-Fifth Annual Corporate Meeting, 11 a.m.; Annual Dinner, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Fri., April 26.—Grand Hotel, Sheffield, Annual General Meeting, "Skidding Resistance of Roads and the Requirements of Modern Traffic," C. G. Giles, 6.15 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Wed., April 24.—SUPPLY SECTION : Savoy Place, London, W.C.2, "Transmission of Electrical Power at 400kV in the Soviet Union," S. S. Rokotyan, 5.30 p.m.
Thurs., April 25.—ORDINARY MEETING : Savoy Place, London, W.C.2, "138kV Submarine Power Cable Interconnecting the Mainland of British Columbia to Vancouver Island," T. Ingledew, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson, 5.30 p.m. ★ IRISH BRANCH : 28, Merrion Square, Dublin, Annual General Meeting, 5.30 p.m.
Mon., April 29.—RADIO AND TELECOMMUNICATION SECTION : Savoy Place, London, W.C.2, Informal Evening on "Radio in Air-Sea Rescue," G. W. Hosie, D. Kerr and W. Kiryluk, 5.30 p.m. ★S. MIDLAND RADIO AND TELECOMMUNICATION GROUP : James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 6 p.m.
Tues., April 30.—S.E. SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, Annual General Meeting, followed by "Applications of Magnetic Amplifiers," C. Cowan, and "Stereophonic Sound," G. I. Thomas, 7 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Thurs., April 25.—N.W. BRANCH : Engineers' Club, Albert Square, Manchester, "Recent Developments in Workshop Metrology," John R. Adams, 7.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., April 23.—N.E. COAST BRANCH : Institute of Mining and Mechanical Engineers, Neville Street, Newcastle upon Tyne, Annual General Meeting, 6.30 p.m.
Tues., April 30.—SCOTTISH BRANCH : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, Annual General Meeting, followed by "Air Conditioning in the British Isles," J. C. Knight, 7 p.m. ★ LONDON ASSOCIATE MEMBERS', GRADUATES' AND STUDENTS' BRANCH : Junior Institution of Engineers, Pepys House, 14, Rochester Row, London, S.W.1, Annual General Meeting, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., April 24.—GENERAL MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Painting and Cleaning of Rolling Stock," F. Fancutt, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Thurs., April 25.—STEAM GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Removal of External Deposits on Boilers," 6.45 p.m. ★ WESTERN A.D. CENTRE : Royal Hotel, Bristol, "Sales and Service in the Transport Industry," J. M. Forbes, 6.45 p.m. ★ N.W. GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, Annual General Meeting, followed by "Engineering Aspects of the Design of High-Speed Aircraft," C. Ellam, 6.45 p.m.
Fri., April 26.—1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting and Annual Report, 6 p.m.
Mon., April 29.—N.E. BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, "Some Engineering Problems in the Industrial Development of Nuclear Power," Sir Claude Gibb, 6 p.m.
Tues. to Thurs., April 30 to May 2.—1, Birdcage Walk, Westminster, London, S.W.1, Conference on "Properties of Materials at High Rates of Strain."

INSTITUTION OF MINING AND METALLURGY

Thurs., April 25.—GENERAL MEETING : Geological Society of London, Burlington House, Piccadilly, London, W.1, "Trace Elements in Sphalerite, Galena and Associated Minerals from the British Isles," E. M. El Shazly, J. S. Webb and D. Williams, and "Stratigraphical and Structural Ore Controls on the Slitt Vein at Heights Mine, Weardale, Co. Durham," R. J. P. Lyon and B. Scott, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., April 29.—N.W. REGION : Great Hall, College of Science and Technology, Manchester, "Human Relations in Industry," J. H. Brebner, 6.30 p.m.
Tues., April 30.—LONDON GRADUATE SECTION : 10, Chesterfield Street, London, W.1, "The Development and Application of Hard Metals," R. N. Cooke, 7.15 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Thurs., April 25.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, 6.45 p.m.
Fri., April 26.—MERSEYSIDE SECTION : Stork Hotel, Liverpool, Annual General Meeting, 6.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., April 30.—WALES AND MONMOUTHSHIRE BRANCH : S. Wales Institute of Engineers, Cardiff, "Wind Stresses on Buildings," H. Ferrington, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Mon., April 29.—SHEFFIELD AND DISTRICT SECTION : Royal Victoria Hotel, Sheffield, Presidential Address, "Fuel Economy and Heat-Electric Generation," Bryan Donkin, 7.30 p.m.
Tues., April 30.—N.W. SECTION : Engineers' Club, Albert Square, Manchester, Presidential Address, "Fuel Economy and Heat-Electric Generation," Bryan Donkin, 7.30 p.m.

PLASTICS INSTITUTE

Tues., April 30.—Lecture Theatre, Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Thermoplastics in the Submarine-Cable Industry," Sir John Dean, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., April 30.—SECTION LECTURE : 4, Hamilton Place, London, W.1, "The Purpose and Problems of Research Aircraft," F. P. Youens, 7 p.m.

ROYAL STATISTICAL SOCIETY

Thurs., April 25.—GLASGOW GROUP : Institute of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Ferranti, Ltd.—Electronic Computers," 7.30 p.m. ★ SHEFFIELD GROUP. Grand Hotel, Sheffield, "Machine Translation and other Uses of Electronic Computers," A. D. Booth, 7 p.m.

SOCIETY OF INDUSTRIAL RADIOLOGY

Fri., April 26.—DISCUSSION GROUP : British Institute of Radiology, 32, Welbeck Street, London, W.1, "Non-Destructive Testing Methods and Techniques," 7 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Wed., April 24.—CONTROL SECTION : Manson House, Portland Place, London, W.1, "Measurement and Control Circuits in the Human Operator," W. K. Taylor, 6.30 p.m.
Tues., April 30.—MAIN MEETING : Manson House, Portland Place, London, W.1, "The Preparation and Industrial Application of Diffraction Gratings," L. A. Sayle, 6.30 p.m.